Q

Standards and Guidelines

The Committee used the following standards and guidelines to achieve the goals and objectives of the conservation strategy and to delineate HCAs on individual State maps.

Goals

- Maintain, over the forest landscape, a population of northern spotted owls that has a high probability of continued existence throughout its range.
- Identify and protect, in the short term, key habitat areas and pairs of owls.

Objectives

The following objectives are to be met within the proposed planning period of 50 to 100 years.

- Manage for continued distribution of breeding pairs throughout the owl's current range.
- Manage for restoration of breeding pairs in key areas of the owl's historic range.
- Manage habitat and owl distribution so that pairs and subpopulations of owls interact genetically and demographically, to minimize risks to long-term viability.
- Monitor and conduct research to evaluate whether the goals and objectives are being met and to facilitate adaptive management.

Description of the Conservation Strategy

The following provides a description and outline of the conservation strategy.

Definition:

Habitat Conservation Area (HCA)

- A contiguous block of habitat to be managed and conserved for breeding pairs, connectivity, and distribution of owls. Application may vary throughout the range according to local conditions. A schematic diagram of the strategy is provided in figure Q1.

Categories of HCAs (table Q1):

- Category 1—blocks of habitat to support at least 20 pairs.
- Category 2—blocks of habitat to support 2 to 19 pairs.
- Category 3—blocks of habitat to support individual pairs.
- Category 4—blocks of habitat that may be smaller than the median annual home-range size but provide connectivity or potential habitat for future nest sites.

Appendix Q: Standards and Guidelines

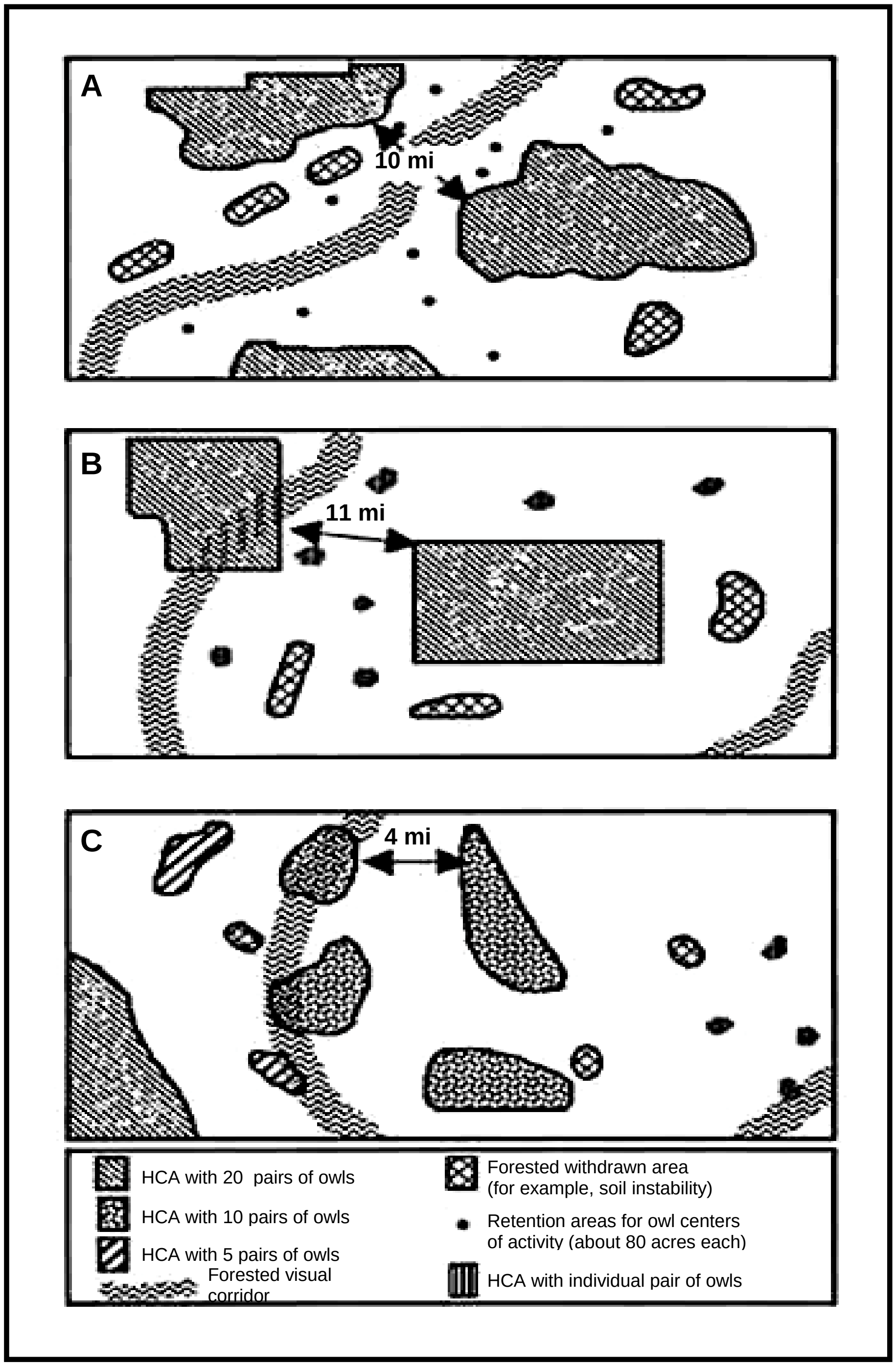

Figure O1—Schematic drawings of the elements of the conservation strategy as it might apply to three different landscapes: scenarios for A, Category 1, ≥ 20 pairs of owls currently; B, Category 1, ≥ 20 pairs not currently present; and C, Categories 2 (2 to 19 pairs) and 3 (blocks to support individual pairs).

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Table Q1—Description of categories

Strategy	Types
Habitat Conservation Area	
Categories[a]:	
1. Blocks of habitat to support a20 pairs	(see figure Q1 and State maps)
2. Blocks of habitat to support <20 pairs	(see figure Q1 and State maps)
3. Blocks of habitat to support individual pairs	a. Small blocks (delineated on State maps) b. Radius-based circle (not delineated on State maps)
4. Blocks of habitat that may be smaller than median annual home-range size	a. Small blocks (delineated) b. 80-acre retention areas (not delineated)
Forest Matrix	
Categories[a]:	
1. Lands suited for timber production:	
• Long rotations	Visual corridors, deer winter range, old-growth retention areas
• Intensively managed lands	Timber production lands
2. Lands unsuited[b] for timber production:	
• Allocation	Stream corridors
• Technical	Soil, regeneration problems
3.Reserved lands[b] outside HCAs:	Parks, Wilderness Area

[a] Categories are listed in order of importance to owls and availability of current or potential habitat.
[b] Although most unsuited and reserved lands are too small or of insufficient quality to be considered part of individual HCAs, some low-elevation areas provide significant amounts of suitable habitat

Intent:

- To assure population viability by providing for long-term occupancy and by reducing risks of local isolation and extinction.
- To support a minimum of 20 pairs wherever possible.
- To provide for owl distribution throughout the range.
- To enhance habitat continuity and quality (that is, maintain the integrity of the interior forest environment).
- To mitigate or reverse local or regional adverse habitat or population trends.
- To hedge against catastrophic loss and adverse effects of timber management (for example, reduce edge effects, mitigate the likelihood of fire or wind effects).

Forest Matrix

Definition:

- All forest lands outside of designated HCAs.

Categories of Forest Matrix (table Q1):

- Lands suited for timber production
- Lands unsuited for timber production
- Reserved lands

Appendix Q: Standards and Guidelines

Intent:

- To provide connectivity for dispersal and interaction of owls among HCAs. See appendix P (figs. P2 and P3) for maps of portions of two National Forests that demonstrate connectivity between HCAs provided by the forest matrix.
- To maintain options for returning owls to the forest matrix by retaining older forest structures in the managed landscape.
- To develop and apply experimental silvicultural treatments that may support a viable owl population in the forest matrix.
- To contribute toward a short-term viable population (less than 50 years).

Guidelines Used in Delineating HCAs

The following guidelines were used to establish the location, size, spacing, shape, and quality of individual HCAs on the enclosed State maps.

Location of Individual HCAs

Location of individual HCAs was based on the following considerations:

- Land ownership (primarily on public lands).
  Note: Some HCAs are recommended for State, tribal, and private lands (dashed lines on State maps). See Description of State Strategy later in this appendix.
- Current and future population distribution to assure viability.
- Occurrence of known pairs and availability of suitable habitat.
- Availability of, or potential for, sufficient pairs to support target densities.
- Ability of reserve lands to support owls.
- Inclusion of the full range of elevational gradients to maintain a diversity of habitats.
- Proximity to other HCAs (see spacing below).

Size of Individual HCAs

HCA size was based on the following considerations (see table Q2 for application):

- The ability of an area to support a minimum of 20 currently known[1] pairs, estimated, or expected based on the presence of pairs, single owls, or the amount of suitable habitat (Category 1).
  The size of the HCA was established by delineating an area to support the target number of pairs using median annual home-range and density information as a guide (see appendix I).
- The inability to support at least 20 pairs because of natural landscape limitations, limited availability of public lands, or local human-induced extirpation.
  The size of Category 2 HCAs (2 to 19 pairs) was established by delineating an area to accommodate as many known, estimated, or potential pairs as possible, using median annual home-range size (see appendix I).

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[1] Currently known pair is defined as the presence of any pair observed Wring the past 5 years within the designated area.

Table Q2—Application of management strategies

Area	Location	HCA Categories
WASHINGTON		
Cascade Province (east and west):		
South Cascades	South of Mount Rainier	1,4 (retention areas)
North Cascades	North of Mount Rainier	2,4 (retention areas)
North Cascades/east	Wenatchee (Entiat and Chelan Ranger Districts) and Okanogan National Forests	3 (radius-based)
Columbia River Gorge	South of Gifford-Pinchot National Forest to river	1
Olympic Peninsula	Olympic Peninsula	1,3 (radius-based)
Southwest Washington	South of Olympic Peninsula and west of Gifford Pinchot National Forest	1
OREGON		
Cascade Province (east and west):		
Cascade/west	California border to Mount Hood	1,2,4 (retention areas)
Columbia River Gorge	North of Mount Hood to river	1
Cascades/east	Deschutes National Forest (north of Bend)	2,4 (retention areas)
	Deschutes National Forest (south of Bend)	3 (radius-based)
Coast Range Province[a]	West of I-S and north of Highway 38	1,2,3 (radius-based)
Klamath Province	Roseburg south into California	1,4 (retention areas)
CALIFORNIA		
Klamath Province:		
North Klamath Mountains	Yolla Bolly Wilderness north into Oregon	1,2,4 (retention areas)
South Mendocino NF	South of Yolla Bolly Wilderness	1,2,3 (mapped) 4 (retention areas)
Cascade/Modoc Province:		
Shasta/McCloud Region	East and north of Clair Engle Reservoir	2,3 (mapped and radius-based) 4 (mapped)
North Coast Range Province	West and south of National Forest	1,2,3,4 (mapped)

[a] For this table, part of the southern coast Range between Highways 35 and *42* are included in the Klamath Province.

The size of Category 3 HCAs (single-pair HCAs) was determined either by (a) using the median annual home-range size (for HCAs delineated on the maps) or (b) using a radius to encompass the estimated home-range size for each State (for those HCAs not delineated on the maps—see Guidelines for Delineating Nonmapped HCAs later in this appendix).

The size of Category 4 HCAs (connector and retention areas) was determined either from (a) the availability of existing blocks under public ownership (for HCAs delineated on the maps) or (b) retention of at least 80 acres of suitable habitat around a known pair's center of activity (for those areas not delineated on the maps—see Guidelines for Delineating Nonmapped HCAs later in this appendix).

Appendix Q: Standards and Guidelines

Shape and Quality of HCAs

The shape and quality of individual HCAs were based on the following considerations:

- Local topography arid distribution of public lands.
- Provision of suitable habitat, or future capability to provide suitable habitat, wtth the structure and composition necessary to support the target number of pairs.
- Provision of contiguous suitable habitat within individual HCAs, given landscape constraints.

Spacing Between HCAs

Spacing between individual HCAs was based on the following considerations:

- A maximum of 12 miles between Category 1 HCAs measured edge to edge (see appendix P).
- A maximum of 7 miles between Category 2 HCAs measured edge to edge (see appendix P).
- Spacing may be closer or farther for all categories of HCAs because of other circumstances or constraints (such as land ownership and landscape potential).

Testing Application of the Guidelines

The following algorithm was used to test the application of the guidelines on the size of each HCA delineated on the State maps. This test was particularly useful in helping to establish HCA size in areas where 20 pairs may not currently exist.

Test 1

Steps:

- We compiled the available home-range and density information by physiographic province; density Information was restricted to density studies—that is, censuses of known areas, not surveys (see appendix I).
- We calculated the median annual home-range size of pairs by using the 100% minimum convex polygon method with an average overlap among adjacent pairs of 25%, which gave an overlap correction factor of (1 – 0.25) = 0.75 (see appendix I).
- We proposed an initial target population size (in number of pair sites) for a specific HCA and calculated the size of the HCA as follows:

  (target number of pairs) X (median annual home-range size) X (0.75) estimated HCA size.

  For example: (20 pairs) X (4000 acres/pair) X (0.75) = 60,000 acres.

- Data used in the test were as geographically specific as possible because attributes such as density and home-range size vary geographically. If necessary, the HCA size was corrected for any included areas of permanently unsuitable habitat such as lakes, towns, and agricultural lands.
- We then determined if the HCA size was within ±10% of the size projected from home-range or density information. If not, HCA size or the projected number of pair sites was re-evaluated or readjusted, as appropriate.

Adjusting Pair Projections From Test 1:

Direct application of the home-range or density algorithms used in Test 1 over-estimate the expected number of pairs, because pair occupancy, at any given point, would be influenced by the dynamic and uncertain nature of past birth and death rates. For the spotted owl, these rates are strongly affected by processes arising from the patchy and irregular distribution of suitable habitat.

Factors that affect dispersal and mating success are functions of HCA size, the amount of suitable habitat within an HCA (percentage of the HCA that is, or will be, suitable habitat), and the spacing among HCAs. In general, smaller HCAs, or those with less suitable habitat, will have lower expected pair occupancy. The goal of the following adjustment is to correct expected pair-occupancy numbers to reflect demographic and mild environmental uncertainty.

Steps:

- The total number of pair sites in an HCA is estimated by both the application of the home-range and density algorithms. These two projections are averaged.
- The number of projected suitable pair sites at 100 years is taken from the results of Test 1, above. The ratio of suitable to total pair sites is an estimate of the percentage of the HCA that is suitable.
- We computed model-based correction factors for average pair occupancy for HCAs ranging from 5 to 30 pair sites. We assumed a constant pair occupancy, and that 35% of the forested landscape was contained within the HCAs.
  According to our estimates of forest land within HCAs and recent FS and BLM statistics, the current estimated percentage of suitable habitat in HCAs in the Pacific Northwest Region is about 38% and about 21% for the Pacific Southwest Region.
- We adjusted previous estimates of future expected pairs (Test 1) to account for HCA size, spacing, future percentage of suitable pair sites, and demographic and environmental uncertainty. Adjustment factors (table Q3) were based on the dynamic, metapopulation model described in appendix M.
  Example: Assume an HCA with a projected number of future suitable pair sites equal to 10, and an estimated total number of pair sites equal to 20. The estimated percentage of sites suitable within the HCA is 50% (=10/20). In this example, the tabulated entry (table 03) we use is for an HCA size of 20 sites and a percentage of suitable sites of 50%. We enter table Q2 at row “20” and column “50.” The correction factor is equal to 0.78. The adjusted, future pairs is then equal to 0.78 X 10 pairs = 8 pairs. (If the total number of sites is not tabulated, we round both to the closest tabulated value.)

Test 2

On completion of the above steps, a draft map for each State was available for testing the logical coherence of one or more map properties, such as HCA size, shape, and connectivity.

Table Q3—Correction for projections of future expected pairs[a]

Total number of pair sites in the HCA	Percentage of HCA pair sites that are suitable							
	30	40	50	60	70	80	90	100
5	26	32	44	45	62	62	68	71
7	29	39	52	54	63	72	74	75
10	32	49	60	68	73	83	85	88
12	43	57	65	70	78	82	88	88
15	46	55	73	77	81	85	87	88
17	47	63	76	79	84	89	90	90
20	54	75	78	85	87	89	92	93
25	65	76	82	88	92	92	93	94
30	65	78	82	88	92	92	93	94

[a] Tabled entries are the expected percentage, mean pair occupancies at 100 years. Computations were based on the assumption that 35% of the forested landscape was within the HCAs. See text for explanation.

Steps:

- We estimated several regression models to test the null hypothesis of no relation between the expected future number of pairs (dependent variable) and HCA size and perimeter (independent variables). The null hypothesis was rejected if one or more of the estimated regression coefficients were significantly different from zero.
- The best-fit regression model[2] for all three States was:

$$\ln(\text{expected prs}) = b_0 + b_1 \ln(\text{HCA size}) + b_2 \ln(\text{HCA perimeter}).$$

- We found, from all three States, a significant regression of expected number of pairs on HCA size and perimeter. Therefore, the hypothesis of logical consistency in this property (HCA expected pairs, size, and shape) of the map was supported.
- We used this regression model to further refine the map and improve its internal consistency. This refinement was done by using regression diagnostics to: determine observations with undue influence on the estimation of the regression model, identify observations with large standardized residuals, or identify HCAs with a large difference between the observed and predicted number of pairs.
- This process was continued iteratively until a satisfactory fit was found between the map and all the information that could be brought to bear to test the properties of the map.

Guidelines to Use in Delineating Nonmapped HCAs

Guidelines for agencies to use in delineating nonmapped HCAs (Category 3 radius-based HCAs and Category 4 retention areas) should consider the criteria stated earlier for mapped HCAs for shape and quality. Guidelines for location and size are explained below; spacing did not apply.

Management of Habitat for Individual Pairs (Category 3)

Maintaining and recruiting suitable habitat around individual pairs is necessary in portions of the owl's range and is a further requirement of this strategy. These areas are to be retained regardless of changes in occupancy. For some Forests and BLM Districts, this requirement is in addition to other strategies (see table Q2 and description of State strategy).

[2] ln = log normal; b = regression factor.

The following areas should establish Category 3 HCAs.
- Washington:
  - Okanogan National Forest
  - Wenatchee National Forest (Entiat and Chelan Ranger Districts)
  - Olympic National Forest
- Oregon:
  - Deschutes National Forest south of Bend
  - Siuslaw National Forest
  - BLM Districts north of Highway 38, west of I-5
- California:
  - Shasta and Klamath National Forests north and east of Clair Engle reservoir and north and east of mapped HCAs

Location

- Availability of existing suitable habitat.
- Occurrence of a known pair or both known and future pairs (for further discussion, see Description of State Strategy later in this appendix).
- For those areas where protection outside of mapped HCAs is an additional requirement, the following applies:

  Olympic Peninsula—protect all currently known pairs.

  Oregon Coast Range (north of Highway 38)—protect all known and future pairs within a 12-mile-wide band around each HCA (measured from the edge) or half the distance to the next HCA if the distance is less than 12 miles.

  Shasta/McCloud Area of Special Concern (north and east of Clair Engle Reservoir within the area of delineated HCAs)—protect all known and future pairs within a 12-rrdle-wide band around each Category 1 and 2 HCA (measured from the edge) or half the distance to the next Category 1 or 2 HCA if the distance is less than 12 miles; protect all known and future pairs in other areas until the possibility of improving the Category 3 situation in these areas can be assessed by the oversight committee established under this strategy.

Pairs outside of Category 1 and 2 HCAs should be protected until the number of pair areas outside the HCA, plus the number of known pairs within that HCA (as verified from 3 consecutive years of surveys), match the projected target for that HCA. The number of pair areas can be reduced proportionally as the number of pairs within the HCA approaches the target for that HCA according to the following formula:

(target number of pairs) - (known number of pairs inside HCA) =
number of pairs to be protected outside HCA.

Example: If the target number of pairs for an HCA is 20 and only 7 pairs are currently known within the HCA, then at least 13 pairs or the number of known pairs (up to 13 after completion of surveys) outside of the HCA must be protected. If three additional pairs are located within the HCA (verified from 3 consecutive years of surveys using standard protocols), the number of pairs (or pair areas) protected outside of the HCA can be reduced by three.

Surveys are sometimes incomplete and present data insufficient to establish the presence of pairs of spotted owls.

In the Shasta/McCloud Area of Special Concern (north and east of mapped HCAs), surveys to verify the presence of pairs of owls must be conducted for 3 consecutive years. Category 3 HCAs should be established for all verified pairs and for the repeated presence (within one location) of single owls during this period until the surveys are completed and the status of the owl population in this area can be determined by the committee established under this strategy.

Size

- Delineate an area of suitable habitat using a circle with a 2.1-mile radius in Washington, a 1.5-mile radius in Oregon, and a 1.2-mile radius California.

  Adjust the circle to include the pair's center of activity (nest site or primary roost area) and the best arrangement of suitable habitat; the center of activity should be at least 1/4 mile from the edge of the HCA, except where precluded by ownership boundaries or past logging.

  Adjust boundaries, if necessary, to follow landscape configurations such as roads, streams, ridge tops, or previous sale boundaries, so long as suitable habitat encompassed by the original circle has not been reduced.

Retention Areas (Category 4)

Centers of activity for currently known pairs of owls will be retained in addition to the HCAs that have been delineated on the maps. These areas will provide potential nesting habitat during subsequent rotations and offer the opportunity to return owls to the forest matrix in the future.

Location

- Occurence of known pairs throughout the owl's range, except in those areas where the only strategy is protection of all known pairs.
- Not to exceed 7 pairs (areas) per township.

Size

- Delineate the stand of trees containing the center of activity (nest site, principal roosting area, or both) and additional suitable habitat in the vicinity until at least 80 acres are designated or a distance of 1/4 mile from the center of activity is reached, whichever occurs first.
- The center of activity need not be located in the geometric center of the designated acres, given topographic features and availability of suitable habitat; the 80 acres should be as contiguous as possible.

Appendix Q: Standards and Guidelines

Management Prescriptions

The Committee believes the following management activities apply and need to be included in the conservation strategy. These management prescriptions apply to federally managed lands and are recommended for other land ownerships.

Management Activities Within the HCA

The HCA is the cornerstone of the conservation strategy. The success of the strategy depends on the habitat conditions in the HCAs. The following elements are important to ensure both short- and long-term viability of the northern spotted owl. To be consistent with the intent of this document, site-specific management plans must be developed for each Category 1, 2, or 3 HCA, explaining allowable, desired, and planned management activities in each area.

Inventory and Monitoring

- Within 3 years, determine owl densities within each HCA.
- Conduct (or have conducted within the past 2 years) at least six owl survey visits with a minimum of three visits in any one year before harvest of all sales under contract and any sales placed under contract in FY90. If pair occupancy is confirmed, refer to Timber Management section that follows.
- Monitor demographic and habitat trends in replicated samples of HCAs in each physiographic province, including banding all owls in selected areas.

Timber Management

- Prohibit timber harvest of any age-class of forest, except:

  Sale units presently under contract that are more than 1/2 mile from the center of activity of a known pair. Modify sales or sale units that are within 1/2 mile of pairs;

  Substitute sales outside the HCA for any currently planned but unsold timber sales for FY90. If substitution is not an option, follow the stipulations described above; and

  Review proposals case by case to remove individual or small groups of trees for administrative needs (for example, hazard trees or rock pit expansion) or for other resource management programs (for example, campground developments).

- Allow silvicultural treatments that have been tested or demonstrated through experimentation to facilitate the development of suitable habitat, such as planting trees (see appendix S).
- Prohibit firewood cutting, except for removal of logging slash from previously awarded units that exceed the dead-and-downed component.
- Prohibit salvage of any downed or standing trees. For special situations where salvage of extensive areas may be proposed, salvage activities must be approved by the interagency body organized to review implementation of the conservation strategy.

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Fire Management

- Prepare a fire-management pan for each HCA.

Road Construction

- Road construction diminishes the quality and amount of owl habitat. Roads should be located in HCAs only when no feasible alternative is possible. When roads are constructed, they should be located and engineered to minimize the loss and alteration of habitat and should be situated at least 1/4 mile from the activity center of any known pair.

Land Exchanges

- Prohibit exchange of forested lands from Federal ownership without approval of the interagency body organized to review implementation of the conservation strategy.
- Consider land exchanges to improve existing HCAs, especially in lands where public and private lands are intermingled (for example, BLM areas).

Mining Operations

- To determine effects on known pairs and suitable habitat, mining activities should be reviewed case by case for approval by the interagency body organized to review implementation of this conservation strategy.

Management Activities Within the Forest Matrix Outside of HCAs

Connectivity and retention of habitat characteristics for future breeding sites are important aspects of the conservation strategy in the long- and short-terms. To assure that adequate dispersal habitat and options to apply adaptive management are available in the forest matrix, the following prescriptions are required within the owl's range.

Reserved Lands

- No decrease will be made in the present direction of management for all forested lands in this category.

Lands Unsuited for Timber Production

- No decrease will be made in the present direction of management for all forested lands in this category.

Lands Suited for Timber Production

- Retain existing considerations for other resource values such as wildlife trees and downed-wood retention.
- Establish 80-acre retention areas (Category 4 HCAs) around known pairs as previously discussed (see Guidelines to Use in Delineating Nonmapped HCAs), where all known pairs are not otherwise delineated.

- For every quarter township, timber harvest shall be permitted only when 50% of the forest landscape consists of forest stands with a mean d.b.h. of 11 inches and a canopy closure of 40% (50-11-40 rule). All land-use allocations on forest lands (except Category 1, 2, or 3 HCAs) and all ownerships within the quarter township contribute to meeting this rule.

Steps:

The percentage of the forest landscape (minus acreage in any Category 1, 2, or 3 HCA) is computed to meet the 50-11-40 rule for the quarter township where the proposed action is located.

Where the quarter township contains multiple ownerships, the percentage is computed separately for each owner, based on the amount of ownership.

> Example: If owner A has 2880 acres in the quarter township, it would have a 1440-acre quota under the 50-11-40 rule before harvest would be permitted. If owners B and C each had 1440 acres, their quota under the rule would be 720 acres of forest stands, each with a mean d.b.h. of 11 inches and a 40% canopy closure.

Prorated quotas will be required for 3 years after the implementation of the conservation strategy. At the end of the 3-year period, the interagency body appointed to oversee the plan's implementation will re-evaluate the 50-11-40 rule as it applies in multiple-ownership areas.

- We recommend experimentation and testing of silvicultural treatments that improve, maintain, or develop suitable habitat over time (see appendix S). A long-term goal is to provide an opportunity for owls to occur in the managed forest matrix at populations sufficient to warrant review of the need to continue HCAs.

Description of the State Strategies

The following provides a brief description of the application of the guidelines used to delineate HCAs that were drawn by the Committee on the enclosed maps for each State (see appendix C and figure C3 for description of Areas of Special Concern).

California

In California, 99 HCAs were established within the three physiographic provinces (table Q4).

Table Q4—Analysis of Habitat Conservation Areas in California (comments on individual HCAs are listed at the end of table)

Habitat Conservation Area	Gross[a] area (acres)	Known[b] pairs	Total[c] estimated pairs	Future[d] expected pairs	Adjusted[e] future expected pairs
Forest Service Lands					
C-1	113,000	14	18	26	25
C-2	55,000	8	17	20	18
C-3	40,000	23	25	24	22
C-4	57,000	19	20	25	23
C-5	83,000	10	18	22	19
C-6	48,000	11	16	20	19
C-7	11,000	7	7	5	3
C-8	145,000	19	30	40	37
C-9	7,000	3	3	3	2
C-10	52,000	14	18	22	20
C-11	183,000	20	28	40	36
C-12	58,000	16	18	24	22
C-13	44,000	15	18	22	20
C-14	45,000	8	8	10	7
C-15	87,000	11	20	21	18
C-16	71,000	7	ii	20	18
C-17	46,000	3	5	14	12
C-18	43,000	2	4	12	10
C-19	29,000	4	4	7	2
C-20	5,600	4	4	3	2
C-21	16,000	1	3	5	3
C-22	4,000	1	1	1	0
C-23	4,800	1	1	1	0
C-24	2,900	1	1	1	0
C-25	400	1	1	1	0
C-26	1,500	1	1	1	0
C-27	2,300	1	1	1	0
C-28	43,000	6	6	6	4
C-29	30,000	2	3	5	2
C-30	14,000	1	2	3	1
C-31	50,000	4	5	7	3
C-32	4,400	2	2	2	1
C-33	3,800	1	1	1	0
C-34	3,000	1	1	1	1
C-35	5,700	1	1	2	1
C-36	2,300	1	1	1	0
C-37	5,500	2	2	2	1
C-38	4,300	0	0	2	1
C-39	3,900	0	0	1	0
C-40	2,400	0	1	1	0
C-41	2,600	0	0	1	0
C-42	64,000	7	10	15	12

See footnote on following page.

Table Q4—continued

Habitat Conservation Area	Gross[a] area (acres)	Known[b] pairs	Total[c] estimated pairs	Future[d] expected pairs	Adjusted[e] future expected pairs
C-43	14,000	2	3	4	3
C-44	11,000	2	2	3	2
C-45	37,000	1	2	4	2
Subtotal		258	341	452	372
Other Federal, State, and Private Lands [f]					
C-46	NA[f]	NA[f]	15	25	23
C-47	26,000	0	3	4	1
C-48	77,000	0	15	30	28
C-49	51,000	2	5	10	6
C-50	67,000	5	8	12	8
C-51	50,000	3	6	10	6
C-52	27,000	3	25	25	23
C-53	4,500	1	2	2	1
C-54	1,000	1	1	1	0
C-55	300	0	0	1	0
C-56	2,500	4	4	2	1
C-57	2,600	0	1	1	0
C-58	1,200	0	?[g]	?[g]	?[g]
C-59	2,900	0	?	?	?
C-60	1,800	0	?	?	?
C-61	3,000	2	2	1	0
C-62	1,400	0	?	?	?
C-63	3,000	1	2	1	0
C-64	9,000	0	2	2	1
C-65	7,300	1	1	2	1
C-66	11,800	0	?	3	1
C-67	6,900	1	1	2	1
C-68	1,500	0	?	?	?
C-69	1,400	0	?	?	?
C-70	1,800	0	?	?	?
C-71	800	0	?	?	?
C-72	11,100	0	2	5	3
C-73	19,600	0	4	8	6
C-74	7,000	0	?	1	0
C-75	4,700	0	?	?	?
C-76	900	0	?	?	?
C-77	1,700	0	?	?	?
C-78	900	0	0	1	0
C-79	2,700	0	?	?	?
C-80	4,800	0	?	?	?
C-81	1,400	0	?	?	?

See footnote on following page.

Table Q4—continued

Habitat Conservation Area	Gross[a] area (acres)	Known[b] pairs	Total[c] estimated pairs	Future[d] expected pairs	Adjusted[e] future expected pairs
C-82	400	1	1	1	0
C-83	600	0	0	1	0
C-84	1,400	0	1	1	0
C-85	1,700	0	1	1	0
C-86	50	1	1	0	?
C-87	700	0	1	1	0
C-88	500	0	1	1	0
C-89	2,200	0	1	1	0
C-90	1,300	0	1	1	0
C-91	700	6	6	1	0
C-92	800	0	0	1	0
C-93	200	0	1	0	0
C-94	4,700	0	0	2	1
C-95	5,000	1	1	1	0
C-96	3,700	0	?	?	?
C-97	1,900	1	1	1	0
C-98	4,900	1	1	2	0
C-99	NA[f]	NA[f]	195	205	185
Subtotal		35	312	370	296
Total		293	653	822	668

[a] Gross acres include all land ownerships within the HCAs, and rivers, lakes, nonforested land, and other areas that will never provide spotted owl habitat. Private lands that may never provide suitable spotted owl habitat are also included.

[b] Number of known spotted owl pairs found in proposed HCAs during 1985-89. Forest Service records were used for National Forests; BLM, National Park, and California Department of Fish and Game records were used for all other lands.

[c] Total numbers of pairs estimated to occur in the HCA. Based on an assessment of several factors that include known locations, home-ranges of owls representative of the area, amounts of suitable habitat, elevation, and intensity of survey effort in the area.

[d] Estimates of the number of pairs that could be expected when habitat fully recovers are based on the factors in footnote 3 above, plus an assessment of the proportion of the HCA that would become suitable. This assumes all pair areas within HCAs are 100% occupied.

[e] Estimates of the number of pairs that could be expected when habitat fully recovers (as above in 4) but adjusted for demographic and environmental uncertainty.

[f] NA = data not available; acreage totals and present number of pairs for BLM, State, and private lands are estimated, habitat capability unknown, or not available; private totals not included until the State-initiated habitat conservation plan is implemented.

[g] Presence of pairs (estimated or future) is dependent upon availability of suitable habitat sufficient to support 1 or more pairs.

Table Q4—continued

Habitat Conservation Area	Comments
C-1 and C-2, C-5 and C-6, C-10, C-12 and C-13 and C-16	These HCAs contain 10 or more estimated pairs; all are expected to support 20 or more pairs in the future. Delineating habitat to support 20 current pairs would have included considerably larger amounts of unsuitable habitat and would have reduced interaction between pairs because of lack of continuity.
C-7 and C-9	These HCAs do not support 20 pairs. Their function is to provide connectivity around a high-elevation Wilderness Area and to HCAs farther east.
C-14	Drier conditions have created a naturally fragmented landscape that may only support an estimated 10 pairs.
C-17 through C-21	This drier and naturally fragmented habitat will not support more than 10 to 15 pairs in the future.
C-22	No other pair opportunity exists, and demographic support for a larger HCA (C-21) is needed at this edge of the subspecies' range.
C-23 through C-27, C-32 through C-41	Because of the naturally fragmented landscape, larger multipair HCAs are riot possible. These HCAs provide connectivity to HCAs to the west and provide the link between the range of the northern spotted owl and the California spotted owl in the Sierra Nevada.
C-28 through C-31, C-42 through C-45	No opportunities exist to support Category 1 HCAs. HCAs are delineated where owls are currently known, future habitat opportunities occur, and where the only demographic support for this local population is possible. Suitable habitat is not uniformly distributed over this region because of moisture and soil conditions.
C-46	Drier conditions have created a naturally fragmented landscape. Owl habitat on private lands is important for connectivity between HCAs and to provide additional support to the local population; this need currently being addressed in the State-initiated conservation plan.
C-47 through C-52	Limited Federal land ownership does not provide opportunities to delineate Category 1 HCAs. These areas are critical for demographic support of the owl population in the northern California Coast Range. HCAs also provide for connectivity with HCAs on FS lands.

Table Q4—continued

Habitat Conservation Area	Comments
C-53 through C-81	All BLM parcels in the Northern California Coast Range Area of Special Concern are delineated as HCAs. Their size and distribution limits the ability of each parcel to support 20 pairs. Two areas may have the potential to support more than two pairs. Many of these small HCAs may not be able to support even a single pair of owls without additional suitable habitat on surrounding State or private lands. The value of these areas is to connect suitable habitats throughout the north coast area and to provide short-term demographic support and future nesting areas in conjunction with suitable habitat on private lands.
C-82 through C-98	These HCAs are small State parks that are managed for their natural forest values. Size and distribution limit their ability to support more than one or two pairs. They are included in this plan, but their role depends on the development of a State-sponsored habitat conservation plan. The value of these areas is the same as that explained above for the BLM parcels.
C-99	This HCA includes all private lands in the North Coastal Area of Special Concern being addressed in the State initiated conservation plan. This plan will provide the long-term demographic base for the owl population in this area and connectivity between public lands.

Category 1:

The HCAs were designated, where possible, on the Six Rivers, Klamath, Trinity, and Mendocino National Forests in the Klamath physiographic province in California. National Forest lands in these areas presently contain some large blocks of contiguous suitable habitat and lands capable of becoming suitable habitat. Limited options exist to delineate Category 1 HCAs because of topographic and landscape conditions; however, 13 Category 1 HCAs were delineated in these areas. Two Category 1 HCAs were delineated in the Coast Range (see below).

Categories 2 and 3:

In addition, 84 smaller HCAs were delineated on Forest Service land and other ownerships to meet the goals and objectives of this strategy, because of such problems as availability of public lands, land ownership, and natural landscape limitations. On the Shasta/McCloud Area of Special Concern, all known and future owls found in areas north and east of the delineated HCAs are designated as Category 3 HCAs. Category 3 designation applies until the species' status is determined for extreme eastern Siskiyou County and Modoc County and better HCAs can be delineated (see previous Guidelines to Use In Delineating Nonmapped HCAs). Otherwise, all known and future pairs of owls located in the area north and east of Clair Engle Reservoir will be maintained as Category 3 HCAs until target densities are reached within this Area of Concern.

Category 4:

Category 4 (80-acre retention areas) will be designated to retain habitat around the centers of activity or known pairs of owls to provide connectivity and opportunities for future nest sites.

State, Tribal, and Private Lands:

Private lands in northern California currently support a significant portion of the spotted owl population in northern California. Inadequate Federal land exists in these areas to fully apply the standards and guidelines to sustain owl viability. Maintaining a viable owl population on these lands is critical. Unless these populations are maintained, a dramatic reduction in the owl population will occur in the coastal area from Mann County north to Humboldt County, and in the area east of Clair Engle Reservoir. Tribal lands in these areas are also important, particularly those of the Hoopa Indian Nation.

We designated the existing large parcels of State and Federal lands as HCAs to maintain multiple pairs. Only two of these HCAs (0-48, 0-52) are capable of supporting 20 or more pairs. In addition, we designated all of the small scattered BLM and appropriate State Park parcels as Category 4 HCAs to provide connectivity, and as habitat to support owls in conjunction with private lands. In the short term, these public lands contribute toward population distribution.

The system of HCAs on Federal lands may result in an average density of about 1.7 pairs per township. Given the owl populations now on private lands in the Shasta/McCloud and northern California Coast range, a similar density on the higher site quality, lower elevation lands in private ownership would be possible. We recommend that a State-initiated habitat conservation plan be written to provide a system to augment owls on Federal lands. Designated HCAs on private lands in the Shasta/McCloud area should provide an area-wide density similar to that on Forest Service lands (1.7 pairs per township). In the northern California Coast Range, tribal and private lands should provide additional suitable habitat so that owl populations achieve an area-wide density similar to that on Forest Service lands (1.7 pairs per township) including all land ownerships. Pairs should be interactive but also maintain wide-spread distribution.

The Committee recommends that surveys should be conducted on tribal lands in consultation with agency biologists, and that HCAs be delineated to complement or support HCAs on Federal lands.

The State of California has expertise in wildlife biology and forestry, a long record of cooperative ventures with private landowners and Federal land management agencies, and legal mandates to regulate forestry practices and manage wildlife on State and private lands. Some private landholders have recently begun to inventory and study the owl. The Committee recognizes that management on private and State lands represents a considerably different scenario than does management on Federal lands. Therefore, we believe that management of suitable habitat on private and State lands should be carried out under the leadership of the State with cooperation of private landowners. The State, with its cooperators, should prepare a habitat conservation plan within 1 year that specifies how the owl population is to be maintained, and how the necessary monitoring and research to guide adaptive management will be carried out.

Oregon

In Oregon, 50 HCAs were established within the four identified physiographic provinces (table Q5).

Category 1:

In the Cascades (west side), Klamath, and southern portion of the Coast Range provinces, 39 Category 1 HCAs were delineated, accounting for nearly 78% of the HCA locations in the State. The other 22% of the HCAs were treated case by case, depending on local habitat conditions. Explanations of these HCAs are contained in table Q5.

Categories 2 and 3:

In addition, 10 Category 2 HCAs were delineated, 5 in the northern portion of the Deschutes National Forest, 3 in the Coast Range Area of Special Concern, 1 as a connector between the Cascades and Coast Ranges, and 1 as a connector to the Goosenest Ranger District in California. For the southern portion of the Deschutes National Forest, Category 3 HCAs will be designated for all known pairs of owls. In the Coast Range Area of Special Concern, Category 3 HCAs will be designated for all additional known and future pairs (see previous Guidelines to Use in Delineating Nonmapped HCAs). Protection of these pairs is necessary until target densities are reached for HCAs within this area of concern. One HCA (O-1) is significantly larger than the others because it occurs in proximity to the Columbia River and constitutes a critical connection between Oregon and Washington. For further details, see Table Q5.

Category 4:

Category 4 (80-acre retention areas) will be designated to retain habitat around the centers of activity or known pairs of owls to provide connectivity and opportunities for future nest sites.

Table Q5—Analysis of Habitat Conservation Areas in Oregon (comments on individual HCAs listed at end of table)

Habitat Conservation Area	Gross[a] area (acres)	Known[b] pairs	Total[c] estimated pairs	Future[d] expected pairs	Adjusted[e] future expected pairs
Forest Service and Bureau of Land Management Lands					
O-1	136,000	8	35	40	37
O-2	67,000	6	20	23	21
O-3	81,000	6	20	25	23
O-4	80,000	8	20	27	25
O-5	75,000	13	20	25	23
O-6	78,000	18	25	25	23
O-7	69,000	19	21	27	25
O-8	93,000	12	24	25	22
O-9	82,000	11	21	26	24
O-10	65,000	9	20	23	21
O-11	17,000	18	22	24	22
O-12	86,000	30	30	26	24
O-13	84,000	10	25	26	24
O-14	80,000	13	24	27	25
O-15	89,000	8	20	23	20
O-16	84,000	19	21	24	22
O-17	55,000	24	25	27	25
O-18	66,000	13	20	22	20
O-19	93,000	14	23	32	29
O-20	67,000	14	20	20	17
O-21	77,000	8	20	24	22
O-22	64,000	13	20	21	20
O-23	115,000	2	20	25	21
O-24	75,000	6	20	22	20
O-25	78,000	9	20	26	24
O-26	86,000	18	21	25	23
O-27	76,000	14	20	30	28
O-28	78,000	21	23	26	24
O-29	60,000	6	15	21	20
O-30	76,000	10	12	27	25
O-31	68,000	10	15	25	23
O-32	68,000	5	11	23	21
O-33	55,000	4	9	22	20
O-34	59,000	5	10	23	21
O-35	53,000	2	5	21	20
O-36	74,000	1	3	28	26
O-37	47,000	3	3	18	17
O-38	18,000	2	3	7	5
O-39	23,000	2	2	5	2
O-40	42,000	6	11	16	14
O-41	8,000	1	1	2	1
O-42	20,000	4	4	4	2

See footnote on following page.

Appendix Q: Standards and Guidelines

Table Q5—continued

Habitat Conservation Area	Gross[a] area (acres)	Known[b] pairs	Total[c] estimated pairs	Future[d] expected pairs	Adjusted[e] future expected pairs
O-43	12,000	2	3	3	1
O-44	11,000	2	2	3	1
O-45	15,000	1	3	3	1
Subtotal	430	732	967		874
State Lands					
O-46	65,000	0	0	25	23
O-47	58,000	0	0	23	22
O-48	65,000	0	2	26	24
O-49	21,000	0	1	4	2
O-50	8,000	0	1	2	1
Subtotal		0	4	80	
Total		430	736	1047	

[a] Gross acres include all land ownerships within the HCAs, and rivers, lakes, nonforested areas, and other areas that will never provide spotted owl habitat. Private lands that may ***never*** provide suitable spotted owl habitat area are also included.

[b] Number of known spotted owl pairs found in proposed HCAs during 1985-89. Forest Service records were used for National Forests; BLM records for all Bureau lands, National Park Service records were used for National Parks, and Oregon Department of Fish and Wildlife records were used for State and Private lands.

[c] Total numbers of pairs estimated to occur in the HCA. Based on an assessment of several factors that include known locations, home ranges of owls representative of the area, amounts of suitable habitat elevation,, and intensity of survey effort in the area.

[d] Estimates of the number of pairs that could be expected when habitat fully recovers are based on the factors in footnote 3 above, plus an assessment of the proportion of the HOA that would become suitable. This assumes all pair areas within HCAs are 100% occupied.

[e] Estimates of the number of pairs that could be expected when habitat fully recovers (as above in 4) but adjusted for demographic and environmental uncertainty.

Table Q5—continued

Habitat Conservation Area	Comments
O-29 through O-36	Low densities of owls prevented delineating HCAs supporting 20 interacting pairs. HCAs were established which, on habitat recovery, will support 20 interacting pairs.
O-37 through O-39	Low densities of owls prevented delineating HCAs supporting 20 interacting pairs. In addition, Federal land is insufficient to create an area capable of supporting 20 pairs even in the future. These HCAs are important for connectivity and as multipair areas.
O-40	This HCA was delineated to provide connectivity to HCA C-28 in California.
O-41 through O-45	The scattered distribution of owls and habitat arrangement on the northern Deschutes National Forest prevented delineating a large HCA capable of supporting 20 pairs of owls either now or in the future.
O-46 through O-49	These HCAs are on lands administered by the Oregon Department of Forestry and fall within the Oregon Coast Range Area of Special Concern. As a result of wildfires, forests are generally 40 to 90 years old. Currently, owl densities are extremely low, but with recovery of suitable habitat, each of these areas could support 20 pairs. These HCAs will provide connectivity from northwestern Oregon to southwestern Washington and the Olympic Peninsula.
O-50	This small HCA is administered by Oregon Department of Forestry. It currently includes some older stands and may support a pair of spotted owls. This HCA also contributes to supporting owl pairs on adjacent BLM lands (HCA O-4).

State, Tribal, and Private Lands:

The HCAs in Oregon are comprised primarily of lands administered by the Forest Service, BLM, and the State of Oregon. In some instances, particularly in the Klamath and Coast Range provinces, the BLM lands are intermingled with private timber company lands. Although management of intermingled lands may not produce superior habitat for owls, we propose that private landowners manage their lands to provide foraging habitat to support owls that are nesting on adjacent BLM lands. The HCAs on lands administered by the Oregon Department of Forestry in northwest Oregon are the sole opportunity for re-establishing the owl in a key portion of its historic range; thus, they are important to the success of this strategy.

The Committee recognizes that management on private and State lands differs considerably from management on Federal lands. Therefore, we believe that management of suitable habitat on private and State lands should be carried out under the leadership of the State with the cooperation of private land owners. The State, with its cooperators, should prepare a habitat conservation plan, as is the State of California, that specifies how an owl population is to be managed, and how the necessary monitoring and research to guide adaptive management will be carried out.

The Committee recommends that surveys should be conducted on tribal lands in consultation with agency biologists, and that HCAs be delineated to complement or support HCAs on Federal lands.

Washington

In Washington, 44 HCAs were established (table Q6).

Category 1:

HCAs were delineated, where possible, on all of the Gifford Pinchot National Forest south of Mount Rainier, including potentially suitable habitat in Mount Rainier National Park and the Goat Rocks Wilderness. One HCA (W-1) was significantly larger than the other two in this area because of its proximity to the Columbia Gorge and concerns for demographic and genetic interaction between owls in Oregon and Washington. See table Q6 for further details.

Geographic areas capable of supporting potential 20-pair areas include the broad band of intermingled ownership lands known as the “I-90 corridor,” the Swauk Pass and Lake Wenatchee regions of the Wenatchee National Forest, and portions of the Darrington and Mount Baker Ranger Districts on the Mount Baker-Snoqualmie National Forest. Six Category 1 HCAs were established in these areas. They are currently estimated to average 10 pairs of spotted owls each.

Categories 2 and 3:

Because of low densities of spotted owls north and east of Mount Rainier National Park, delineating HCAs that could currently contain 20 pairs would require the inclusion of broad geographic areas that would probably not function to provide suitable habitat for an interactive subpopulation. This area includes all of the Mount Baker-Snoqualmie, Wenatchee, and Okanogan National Forests and the North Cascades National Park. Much of the moderate elevational forest land that exists in this region has been heavily logged and supports reduced populations of owls. Therefore, 24 Category 2 HCAs were delineated in these areas.

Because of the low number and patchy distribution of suitable owl habitat in the northeast Cascades, all known pairs on the Okanogan National Forest and Entiat and Chelan Ranger Districts of the Wenatchee National Forest are designated as Category 3 HCA’s (see previous Guidelines to Use in Delineating Nonmapped HCAs).

Table 06—Analysis of Habitat Conservation Areas in Washington (comments on individual HCAs listed at end of table)

Habitat Conservation Area	Gross[a] area (acres)	Known[b] pairs	Total[c] estimated pairs	Future[d] expected pairs	Adjusted[e] future expected pairs
Forest Service and National Park Lands					
W-1	176,000	20	23	35	33
W-2	146,000	22	24	28	26
W-3	132,000	17	21	25	23
W-4	140,000	12	12	30	28
W-5	126,000	7	9	25	23
W-6	119,000	11	15	25	23
W-7	112,000	6	10	22	21
W-8	111,000	4	5	23	22
W-9	106,000	11	11	20	19
W-10	49,000	3	3	10	9
W-11	16,000	2	2	3	2
W-12	26,000	2	3	4	2
W-13	13,000	2	2	2	1
W-14	10,000	2	2	2	1
W-15	35,000	1	3	6	4
W-16	59,000	8	9	12	11
W-17	28,000	1	1	5	3
W-18	29,000	2	2	4	3
W-19	67,000	2	2	2	1
W-20	23,000	3	3	4	2
W-21	11,000	2	2	2	1
W-22	8,000	1	2	2	1
W-23	13,000	1	2	2	1
W-24	39,000	6	7	7	5
W-25	25,000	2	2	4	2
W-26	27,000	4	5	5	3
W-27	15,000	2	3	3	2
W-28	73,000	5	8	12	10
W-29	27,000	0	2	5	3
W-30	16,000	1	2	3	2
W-31	23,000	1	2	4	3
W-32	41,000	3	4	7	5
W-33	39,000	0	2	5	3
W-34	101,000	0	5	14	11
W-35	16,000	0	1	2	1
W-36	676,000	54	131	146	137
Subtotal		220	344	518	454
State and Other Federal Lands					
W-37	12,000	1	1	1	0
W-38	64,000	4	5	8	6

*See **footnote on** following page.*

Table Q6—continued

Habitat Conservation Area	Gross[a] area (acres)	Known[b] pairs	Total[c] estimated pairs	Future[d] expected pairs	Adjusted[e] future expected pairs
W-39	82,000	0	0	17	15
W-40	129,000	0	0	27	25
W-41	104,000	0	0	22	20
W-42	94,000	1	4	20	19
W-43	68,000	0	0	14	12
W-44	33,000	0	0	6	4
Subtotal		6	10	115	101
Total		226	354	633	555

[a] Gross acres include all land ownerships within the HCAs, and rivers, lakes, nonforested areas, and other areas that will never provide spotted owl habitat. Private lands that may never provide suitable or superior spotted owl habitat are included.
[b] Known locations of spotted owl pairs found in proposed HCAs during 1985-89. Forest Service records were used for National Forests. Washington Department of Wildlife and National Park Service records were used for National Parks, and Washington Department of Wildlife records were used for State and private lands.
[c] Total numbers of pairs estimated to occur in the HCA. Based on an assessment of several factors that include known locations, home ranges of owls representative of the area, amounts of suitable habitat, elevation, and intensity of survey effort in the area.
[d] Estimates of the number of pairs that could be expected when habitat fully recovers are based on the factors in footnote 3 above, plus an assessment of the proportion of the HCA that would become suitable. This assumes all pair areas within HCAs are 100% occupied.
[e] Estimates of the number of pairs could be expected when habitat fully recovers (as above in 4) but adjusted for demographic and environmental uncertainty.

HCA number	Comments
W-4 through W-9	These HCAs are currently estimated to contain fewer than 20 pairs of owls, each with potential to increase to 20 pairs. Smaller, multipair areas were delineated in this area to address local demographic, distribution, and linkage concerns.
W-1 0	This HCA is surrounded by intensively managed private timber lands and is separated from the Gifford Pinchot National Forest by about 12 miles. It is important for genetic connectivity between the Cascade Range and the Olympic Peninsula.
W-11 through W-35	Because of natural habitat limitations and low population densities, HCA’s were delineated for potentially 2 to 14 pairs of owls.

Table Q6—continued

HCA number	Comments
W-36	An HCA was established around the Olympic National Park to increase habitat connectivity between major drainages, to include habitat at a variety of elevations, and to support a potentially isolated population.
W-37, W-38	These HCAs are adjacent to the Olympic National Park on State lands administered by the Washington Department of Natural Resources. These HCAs are necessary to demographically support the local owl population.
W-39 through W-41	These HCAs are located on lands administered by the Washington Department of Natural Resources. Forests are generally less than 70 years old as a result of windstorms and logging. Although no owls are presently known to occur here, these HCAs are necessary to improve connectivity between the Olympic Peninsula, the Oregon Coast Range, and the Washington Cascades.
W-42	This HCA is important to maintain demographic connectivity between the Oregon and Washington populations of owls.
W-43	This HCA is located entirely on the Fort Lewis Military Reservation. Forests are generally less than 70 years old. We recommend that lands be managed to improve connectivity with the Washington Cascades and the Olympic Peninsula population.
W-44	This forest land is administered by Washington Department of Wildlife. Stands are generally less than 30 years old but are expected to provide future owl habitat. When combined with HCA W-16, they form a contiguous block capable of supporting about 20 pairs of owls.

Category 4:

Category 4 (80-acre retention areas) will be designated to retain habitat around the centers of activity or known pairs of owls to provide connectivity and opportunities for future nest sites.

Olympic Peninsula:

On the Olympic Peninsula, one large HCA (W-36) was delineated to encompass a contiguous band of habitat surrounding the perimeter of Olympic National Park. Potential owl habitat essentially takes the shape of a large doughnut, with the center being an impassable mountain barrier. This band of habitat will provide for a well-distributed population at a range of elevations on the Olympic National Forest, and will increase connectivity between large tracts of habitat in major drainages of the Peninsula. In addition, all currently known pairs in the Olympic Peninsula Area of Special Concern are designated as Category 3 HCAs. Protection of these pairs is necessary until the target density is reached for the HCA established in this area.

Two smaller HCAs (W-37, W-38) were delineated on State lands adjacent to Federal lands on the Peninsula. Both HCAs will be contiguous with W-36, and add to the number and distribution of spotted owls on the Peninsula. The Committee strongly recommends to the State of Washington that these HCAs be established.

Other State, Tribal, and Private Lands:

Four HCAs (W-39 to W-42) were delineated on State lands in southwest Washington and the Columbia Gorge. These HCAs are located in Areas of Special Concern, and we strongly recommend to the State of Washington that they be established. An HCA (W-17) was delineated in the Cedar River Watershed near North Bend. Lands within W-17 are comprised of alternating sections of City of Seattle and Forest Service ownership. The Committee strongly recommends to the City of Seattle that they manage their lands within this area as an HCA.

The Committee recognizes that management on private and State lands differs considerably from management on Federal lands. Therefore, we believe that management of suitable habitat on private and State lands should be carried out under the leadership of the State with the cooperation of private land owners. The State, with its cooperators, should prepare a habitat conservation plan, as is the State of California, that specifies how an owl population can be managed, and how the necessary monitoring and research to guide adaptive management will be carried out.

Spotted owls are known to occur on lands of the Yakima and Quinault Indian Nations. No HCAs were delineated on these or other tribal lands because maps and habitat information are lacking. The Committee recommends that Indian Nations, in consultation with State and Federal biologists, establish HCAs on their lands to maintain connectivity between HCAs on Forest Service lands.

Summary of Acreage Totals in HCAs for All Lands

Table Q7 contains an estimate of the gross acreage totals by land ownership for those lands included in the HCAs delineated on the State maps. Acreage for non-mapped HCAs are not included.

- Gross areas include all lands within the designated borders of each HCA regardless of their potential for owl habitat (for example, roads, lakes, meadows), actual amount of currently suitable habitat within HCAs was not calculated.

- Acres of habitat within Wilderness Areas are totaled separately. Acres for other reserved or withdrawn areas have not been calculated; they are included in the totals for all lands (other than Wilderness Areas).
- Acreage estimates for lands suited for timber production are included in the total column with other reserved and withdrawn lands; they are not identified separately.

Table Q7—Estimated acreage by State and agency in mapped HCAs[a]

State Agency	Wilderness Areas or Parks	Outside Wilderness Areas or Parks	Total
California			
Forest Service	365,000	1,199,000[b]	1,564,000
Bureau of Land Management	5,000	175,000[b]	180,000
National Park Service	86,000	—	86,000
State[c]	129,000	50000	179,000
Private[d]	—	N/A	N/A
Subtotal:	685,000	1,424,000[b]	2,009,000
Oregon			
Forest Service	447,000	1,381,000[b]	1,828,000
Bureau of Land Management	15,000	749,000[b]	764,000
National Park Service	—	—	—
State[c]	—	204,000	204,000
Private[d]	—	N/A	N/A
Subtotal:	462,000	2,334,000[b]	2,796,000
Washington			
Forest Service	313,000	1,627,000[b]	1,940,000
Bureau of Land Management	—	—	—
National Park Service	537,000	—	537,000
Other Federal (Fort Lewis)	—	67,000	67,000
State[c]	—	375,000	375,000
Private[d]	—	N/A	N/A
Subtotal:	850,000	2,069,000[b]	2,919,000
Summary - California, Oregon, and Washington			
Forest Service	1,125,000	4207000[b]	5.332,000
Bureau of Land Management	20,000	924,000[b]	944,000
National Park Service	623,000	—	623,000
Other Federal (Fort Lewis)	—	67,000	67,000
State[c]	129,000	629,000	758,000
Private[d]	—	N/A	N/A
Total:	1,897,000	5,827,000[b]	7,724,000

[a] These are gross acreage figures (rounded to the nearest 1000) that include all land types within HCAs, including lakes, streams, roads, meadows, and other land forms that may never be owl habitat; acreage nonmapped HCAs have not been calculated.

[b] Includes 20 to 30% (actual estimates not calculated) lands allocated to uses other than timber production such as roadless recreation areas, riparian corridors, and wild and sonic rivers, or lands unsuitable for timber production because of unstable soils or tree regeneration problems; the balance may be currently suited for timber production.

[c] Acreage of State lands recommended to be included in the HCAs.

[d] Private land acreages in HCAs are not applicable (N/A) and were not included in table; the Committee recommends that private land owners modify forest practices through innovative silviculture so that lands both inside and outside HCAs can support spotted owls.

R

Adaptive Management

Introduction

Although significant information attests to the effects of widespread clearcutting in sites occupied by spotted owls, we do not know how to schedule timber harvests safely in and around habitats occupied by spotted owls. Thus, we recommend an initially conservative strategy that protects spotted owls in HCAs. Here, we propose a responsive process that combines monitoring and research into a dynamic program that can evaluate and incrementally improve the conservation strategy, and also deliberately probe for new information that may increase compatibility between forestry and spotted owls.

The program explicitly promises, as rapidly as can be developed, an objective examination of the possible management-option combinations that may result in minimizing opportunity costs to wood production while maintaining a well-distributed and persistent population of spotted owls. Modifications to the conservation strategy that result from the monitoring and research program may range from increasing protection to allowing timber harvests inside HCAs, where and when either is deemed consistent with objectives for spotted owls. Any such scenarios for spotted owl management must be based on new information and experience expressly sought by implementing and testing the conservation strategy as a management hypothesis that may be modified or rejected in favor of an alternative.

Questions about the long-term effects of the conservation strategy on the persistence of spotted owls cannot be answered with a high degree of precision or certainty, and they require unacceptable amounts of time. Instead, we suggest answering the alternative question, **"What are the available and potential landscape configurations and forest stand treatments that might improve habitat and distribution of spotted owls, and how can such strategies be implemented most effectively?"** Management experiments can answer the latter question fairly quickly by simultaneously testing hypotheses associated with the conservation strategy and specific alternative options.

Adaptive Management Concepts

Adaptive management is a process that can improve management practices incrementally by implementing plans in ways that maximize opportunities to learn from experience. Adaptive management (Eberhardt 1988; Holling 1978; MacNab 1983, 1985; Romesburg 1981; Walters 1986) can provide a reliable means for assessing the conservation strategy, producing better ecological knowledge, and developing appropriate modifications to improve forest management. The primary challenge for using an adaptive management approach is to demonstrate simply and clearly why a change in management would be worthwhile.

Appendix R: Adaptive Management

Two types of adaptive management activities are possible: passive and active (Walters 1988, Waiters and Hilborn 1978). Passive adaptive management implements the best consensus plan as if it were correct. Subsequent monitoring gives better estimates (for example, for home-range size), and mistakes point the way to improve management. When resources are renewable only over long periods, however, such as the structural components commonly associated with old-growth forests, passive adaptive management could lead to resource depletion in the short run (Walters 1986). Moreover, by itself, passive adaptive management cannot provide answers to ecological questions on underlying biological processes. Most importantly, passive adaptive management cannot reveal additional options for consideration by managers.

On the other hand, active adaptive management implements policy decisions in the form of rigorously designed management experiments, which force a blending of monitoring and research. Active adaptive management can evaluate the conservation strategy and seek to answer ecological questions that bear on that strategy. Moreover, active adaptive management can lead to broader options that may alter the course of management. Therefore, we recommend a carefully orchestrated, active adaptive management program.

The active adaptive management program described herein should be predicated on the broad question, "What landscape- and stand-scale management experiments can lead to a greater understanding of the key ecological processes that most influence population viability of spotted owls?" Active adaptive management should provide the fastest and most efficient means for the agencies to determine if the simultaneous goals of maintaining population viability for northern spotted owls and sustaining forestry to produce wood products can be attained. If so, the program should also discover the means by which the goals may be achieved. Note that active adaptive management can be applied to other resource topics associated with integrated forest management.

Concept of Management Experimentation

The challenge to testing hypotheses in the conservation strategy is to verify that spotted owl populations will persist through natural disturbance events, alternative harvest schedules, and modified forestry practices within and between HCAs. Management experiments involving spotted owls in the managed forest matrix provide the basis for ultimately using silvicultural treatments in the HCAs, if such management produces habitat for spotted owls that successfully reproduce over time and over sufficient areas.

Simultaneous evaluation of the conservation strategy and the various options that may be applied is the major strength of the adaptive management program. We have identified several strategies for landscape mosaics (appendix Q) and stand management treatments (appendix S) that may be applied in different areas and under different conditions. Some alternative landscape and stand strategies already have been implemented in some areas in the course of pursuing other management objectives. Research and monitoring of owl responses to the prescribed strategy and to alternative landscape mosaics and various stand treatments will provide essential information for suggesting potential changes to the course of management.

Appendix R: Adaptive Management

We believe the spotted owl population response to implementing the conservation strategy will be manifest only over broad scales of space and time, because of relatively sparse population densities and expected delayed responses to habitat changes associated with the owl's long life span and fidelity to nesting sites (Noon and Biles 1990). Also, the basic biological processes involved (for example, juvenile dispersal, habitat selection, and population regulation) require detailed research investment. Therefore, we must achieve an understanding of spotted owl responses to the landscape pattern, as well as to the dynamics of forest stands, because these are manageable components that link spotted owls to their environments.

Suggested Research and Monitoring Program

In active adaptive management, research blends with monitoring. While monitoring tests hypotheses specific to the conservation strategy, research will compare predictions and assumptions of hypotheses stemming from the conservation strategy and alternative landscape options and stand treatments. Thus, we recommend giving high priority to research projects that are designed to make use of data collected in monitoring.

Recent field evidence suggests that some suitable habitat for northern spotted owls has resulted from previous forestry practices, as indicated by owls in relatively high owl densities and evidence of breeding. This phenomenon has been observed in some northern California forests, in a few western Oregon areas, and in some selectively harvested forests east of the Washington Cascades (Irwin 1989, Irwin et al. 1989a, b). If such forestry practices fortuitously produced suitable habitats where owls can breed successfully, suitable habitat probably could be produced by silvicultural design in the same forests and possibly in other forests. Such options, discussed in appendix S, provide opportunities for management experiments to enlarge the zone of compatibility between spotted owls and forestry practices.

The following sections for research and monitoring align with an emerging interest within agencies and the scientific community to increase the retention of large trees, snags, dead-and-downed woody debris; to minimize the effects of fragmentation; and to extend harvest rotations in some areas. For example, these interests have resulted in a new FS research and development program on "New Perspectives in Forestry" that aims to balance biological diversity with management practices that produce a sustained supply of goods and services.

We propose a series of management experiments from which research and monitoring can evaluate hypotheses about relationships between spotted owls and their environments, and can determine how those relationships may be affected by implementing the conservation strategy and various options. Alternative management strategies listed in appendix Q and specific testable hypotheses identified by the Committee are listed in table R1. Locations where the specific hypotheses could be tested most effectively and efficiently should be identified (perhaps by geographic information system (GIS), as described below), because they provide opportunities to evaluate predictions inherent in the conservation strategy. Also, as timber harvest proceeds in the forest matrix, some landscapes will "pass through" various options that could be associated with the selected landscape strategy, as the HCAs become more distinct from the surrounding managed-forest mosaic.

Appendix R: Adaptive Management

Table R1—Matrix of testable null hypotheses associated with the conservation strategy and associated options

Strategy	Hypotheses for testing in adaptive plans
HCA+managed mosaic landscape	Population size in HCAs with ≥20 pairs is not declining over the long run
	HCAs do not receive sufficient immigrants per generation to maintain genetic diversity
	Reproductive rate among spotted owls is not related to their population density
	Dispersal success and recruitment rate within HCAs are not different from those rates determined for owls in intervening areas
	Successful dispersal between HCAs does not vary with size of HCAs or distance between them
	Successful dispersal between HCAs does not vary with degree of fragmentation within HCAs or the managed mosaic
	Turnover rate of adults does not vary with population density or amount and fragmentation of suitable habitat within HCAs
	Population growth rate of owls in HCAs with >20 pairs is equal to that in HCAs with <20 pairs
HCA-pairs	Reproductive success of pairs in HCAs is not affected by immigrating adults displaced from areas of timber harvest
	Reproductive success of pairs along the edge of HCAs is equal to that of pairs in the interior
	Elevation, stand conditions, and stand structure of superior habitat does not vary among the physiographic provinces
Matrix pairs	Availability of nest sites does not limit spotted owl density in developing forests
	Prey availability is not related to stand density or stand structure
	Forest fragmentation has no influence on occupancy and reproductive success by spotted owl pairs
	Microhabitat use by spotted owls is not related to amount and distribution of downed woody debris, snags, or stand structural condition
	Small patches of mature and old-growth forests are not used by dispersing owls

Table R1—continued

Strategy	Hypotheses for testing in adaptive plans
	Spotted owls occurring in small patches of forest suitable for nesting surrounded by forests suitable for foraging reproduce as often as those with large amounts of superior and suitable habitat
	Modified silvicultural techniques provide for occupancy and reproduction of spotted owls that are equal to those in unharvested sites
HCA+single-pair HCA landscape	Populations of owls in HCAs with intervening single-pair HCAs are not less stable than those in HCAs plus additional owls in the intervening matrix
Pairs	Reproductive success is not related to fragmentation within and among HCAs with small numbers of pairs
	Occupancy and reproductive success in single-pair HCAs is equal to that of pairs in HCAs with 20 pairs
	Successful dispersal is not related to distance between single-pair HCAs
HCA+connectivity landscape	Dispersal success is not related to indices of connectivity of the managed forest mosaic
	Subpopulations of owls in HCAs with connectors of suitable habitat are not more stable that those without corridors
Long-rotation landscape	Population growth rate of spotted owls in forests managed under long rotations is equal to that for owls in HCAs

Monitoring Program

The set of clearly defined, measurable objectives described in appendix Q, in association with testable hypotheses listed in table R1, provides a quantified basis for monitoring to evaluate and improve the conservation strategy. We propose to test those hypotheses by monitoring spotted owls and habitats in sampling units that include two HCAs and the intervening forest mosaic (fig. R1). The number of units to be monitored in each physiographic province would be set, after consultation with statisticians, relative to specific hypotheses to be tested. Owls in each unit would be sampled as in current demographic studies. All adults would be individually marked by colored leg-bands. Intensive searches would be conducted annually to locate all birds (in both the HCAs and the intervening matrix). All newcomers and young would be banded.

Appendix R: Adaptive Management

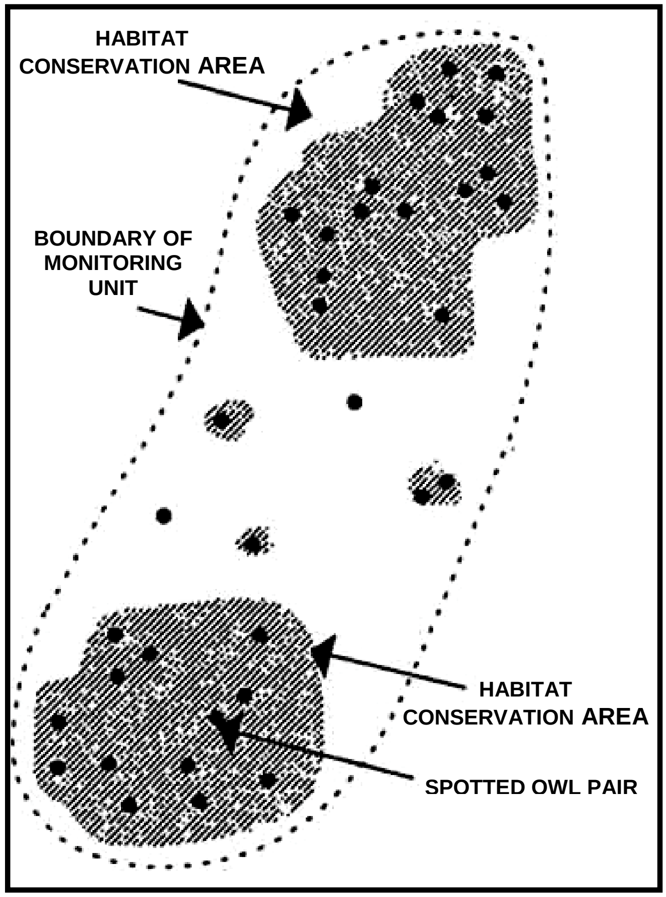

Figure R1—Suggested sampling unit for monitoring spotted owl responses to the conservation strategy.

Important measurements include juvenile survival and dispersal success relative to the size of the HCAs, the amount and arrangement of habitat within the HCAs, and to other factors, such as the distance between HCAs and the composition and configuration of the intervening matrix, or mosaic of managed forest patches. Included, for example, would be measures of habitat fragmentation and distances between nodes of suitable habitat. Sex ratio, reproductive rates, indices to social patterns (for example, mate fidelity), and turnover among known adults also are important parameters. Over time, age-specific reproductive rates could be determined to aid informative demographic projections or population viability analyses.

Monitoring habitats in HCAs would include measures of the proportion of suitable habitat, the area of each suitable stand, indices showing forest fragmentation (Forman and Godron 1986, O'Neill et al. 1988, Turner 1989), and distances to the nearest adjacent HCA and patch (>25 acres) of suitable habitat (that is, a node or area occupied by one or more pairs). For nodes and pair-areas in the matrix, habitat measures might include indices to fragmentation and amounts of suitable habitat.

Appendix R: Adaptive Management

The Committee recognized the inherent fallacy in a monitoring plan that only serves to point out problems or mistakes (for example, increasing mortality rates or habitat loss). Monitoring also should be capable of pointing out positive influences on owl welt are. For example, management treatments, such as fertilization or modified silvicultural practices (see appendix S), might improve numbers and availability of prey, which may result in improved reproduction and survival among spotted owls. Or developing methods for determining the rate of owl colonization in managed forests might be useful. Random sampling for owls in 1000-acre sites in the forest matrix and in pristine, reserved areas may be a way to determine the rate of colonization, with sites picked by using stratified random sampling procedures and GIS (described below).

Additional work is required to establish the sampling design for the revamped monitoring program, which should be tied to the objectives for evaluating each parameter of interest. The sampling design would include sample sizes and acceptable precision and accuracy for estimating parameter values, according to the degree of reliability desired for detecting differences (changes). Sample sizes required to detect certain amounts of change (for example, in reproductive rate) that may trigger changes in statistical management also may involve power analysis (Zar 1984). Power analysis provides a way to reduce Type 2 statistical errors—concluding no difference existed in parameters measured when, in fact, differences did exist. The consequence of Type 2 errors (failing to reject a false null hypothesis) might include the failure to modify management appropriately and at the right time.

Additional Inventory Suggested

Although owl surveys have been extensive in some areas, not all forests that may support owls have been surveyed adequately, and some extensive areas of forest remain unsurveyed. Surveys are needed in the backcountry of all of the large Parks, most Wilderness Areas, and private and State lands in all three States, particularly along the Pacific Coast. Uncertainty also exists about the range of forest types used by the owl in many areas. Moreover, intensive, field-based inventory efforts are needed for most lands to determine the distribution and amount of suitable habitat. Some specific areas needing owl surveys that were brought to our attention include the following list.

Washington—Olympic National Park, North Cascades National Park, Fort Lewis Military Reservation, tribal and State lands on the Olympic Peninsula and the east side of the Cascades, and lands within the Columbia Gorge.

Oregon—Clatsop, Elliott, Santiam, Sun Pass, and Tillamook State Forests; State Parks; Grand Ronde, Warm Springs, Siletz Indian Reservations; and Crater Lake National Park.

California—Point Reyes National Seashore, Whiskeytown National Recreation Area, Redwood National Park, State Parks on the north coast, the Hoopa and Round Valley Indian Reservations, and the foothill oak woodlands of the Sacramento Valley.

Appendix R: Adaptive Management

Research Program

We emphasize strong attempts to gather research information from owl pairs that will be influenced by timber harvesting in the forest matrix between HCAs. We further suggest that some research should be undertaken in full cooperation among concerned groups, who can help by implementing specified silvicultural treatments as part of management experiments.

In addition to testing the hypotheses listed in table R2, the most important research questions that bear on adaptive management can be answered through experimental designs that account for variation in habitat conditions in managed stands and landscapes. For example, by expressly examining spotted owl responses to structural variation in stand conditions or successional stages, management experiments may be useful in developing new silvicultural options.

Simultaneous hypothesis-testing associated with the conservation strategy and alternative options for managing landscapes and stands requires a clear appreciation for functional relationships operating at each ecological scale. Important landscape-scale interactions include responses of dispersing juveniles and nonterritorial adults (floaters) to the several landscape mosaics. Understanding functional relations at the stand scale requires detailed knowledge of basic structural determinants of habitat selection, or of the habitat niche. Understanding the habitat niche provides a basis for maintaining or creating owl habitat by using silvicultural treatments. The envisioned research program, therefore, seeks reliable information on juvenile dispersal, basic determinants of habitat selection, and factors that regulate spotted owl populations at landscape scales.

Foreman et al. (1984) pointed out that young Douglas-fir forests in western Oregon provide at least marginal foraging habitat after 25 to 35 years of development. Silvicultural treatments may be able to accelerate the development of marginally suitable habitat (as defined in appendix F) from unsuitable habitat via precommercial and commercial thinnings. If sites within the forest matrix between HCAs occur in forests younger than about 60 years, then habitat-selection studies could examine owl response to thinnings or other silvicultural treatments, such as under-planting for a second tree layer.

Spotted owls occurring in the forest matrix between HCAs could provide opportunities for understanding potential threshold responses by pairs and individuals to fragmentation. Specific locations where such research could be undertaken were discussed in appendix C. Other sites include sections (square miles) of State ‘school” lands that may represent small amounts of suitable habitat embedded within a matrix of advanced successional stages.

Additional understanding could be developed by tracking owl responses to increasing fragmentation in habitats surrounding core-area patches that are recommended for retention (that is, 80 acres within 1/4 mile of nest sites or core areas). For example, an ongoing study is examining several measures of forest fragmentation at 100 of over 450 known owl sites on BLM lands in western Oregon (Meyer et al. 1990). Preliminary data suggest that site selection may be affected by the amount and stand-size of superior habitat up to 8800 acres around owl sites, but site selection is influenced most strongly within an inner core of 500 acres. A core area of 500 acres fits theoretical predictions based on body size (Irwin 1986).

Appendix R: Adaptive Management

Table R2—List of additional research questions associated with the conservation strategy according to topic and scale of application

Stand- or drainage-scale or individual-pair considerations
Habitat studies
What range of forest conditions is occupied by the owl in each province?
What age and condition in forests support successful reproduction?
What components should be used in developing a reliable habitat capability model?
Prey studies
What is the relation between prey size and owl abundance and reproductive success?
What is the relation between dwarfmistletoe and populations of owl prey?
How can silvicultural practices be used to produce a more diverse and accessible prey base?
How does forest fertilization influence populations of prey for spotted owls?
Studies of movements, physiology, and behavior
What happens to adult owls displaced from areas that are intensively harvested?
What is the effect of transmitters on movements, home range, and habitat use?
How does social facilitation play a role in reproductive behavior?
What are the energetic costs and benefits of capturing prey in different habitats?
What specific stand structural features influence habitat use by spotted owls in each physiographic province?
Do artificial nest structures induce owls to use intermediate-aged forests without nesting opportunities?
How do owls respond to small clearcuts (< 100 feet in diameter) with larger intervening leave patches?
What limits the elevational and latitudinal distribution of northern spotted owls in each province?
Can young spotted owls be imprinted on relatively young forests so they return as adults to breed there?

Table R2—continued

Landscape-scale or population considerations
Demographic studies
What rate and amount of timber harvesting can occur without impacting owl reproduction or survival?
What factors influence owl recolonization of forests that have been harvested and regenerated?
How does marginal habitat influence juvenile dispersal, provide habitat for floaters, or both?
How do population dynamics of owls in highly fragmented areas, such as on BLM ownership, compare to those for owls in less-fragmented forests?
Habitat
How can forest harvests be scheduled over time and space to maintain spotted owl habitat in sufficient amount and distribution so as to perpetuate a breeding population?
What are the fire- and timber-management histories of sites in managed forests that have breeding owls?
How much marginal, suitable, and superior habitat exists in each physiographic province?
Community studies
What is the influence of fragmentation on the relation between spotted owls and great horned owls?
To what extent does competition with barred owls influence populations of spotted owls?
Modeling studies
What is the most reliable structure for a spatially explicit model that predicts population persistence of owls in relation to the landscape mosaic?

Also, mature and old-growth forest stands in the forest matrix provide opportunities to examine owl responses to a variety of current and innovative silvicultural treatments. Monitoring owls in these sites within the matrix may aid in understanding landscape-scale questions that relate to connectivity to larger patches by having corridors or "stepping stone" patches of foraging habitat.

Additional important research includes the need to develop a reliable model that integrates the dynamics of pairs and habitats over time and space to predict the probability of long-term persistence in association with the conservation strategy. Also, forest-growth models that contain critical features of spotted owl habitat must be developed. Finally, other tools are needed, such as a spatially explicit model of landscape relationships linked to a habitat-relationships model that predicts stand conditions. Together, these models could enhance the ability to predict the consequences of management decisions over space and time.

We developed an additional list of questions for research (table R2) through our discussions and from topics raised in the appendices. Some questions address assumptions and predictions of theories that relate to interactions of population and habitat.

GIS: Suggested Technology to Aid Research and Monitoring

We recommend that the monitoring and research programs develop and use GIS. These systems can be defined as automated, internally referenced, spatial information systems designed for data management, mapping, and analysis (Berry 1987a). A GIS can be linked to computer models for spatial-pattern analyses, forest growth and yield projections, and habitat capability indices, expanding the ability to integrate space and time into monitoring and planning management experiments. For example, a GIS could store locational data on forest inventory by categories (for example, age-and structure-class), and be able to simulate future landscapes, including the probability of fire, windstorms, and other catastrophes. The GIS eventually selected should be standardized across the range of northern spotted owls.

The GIS also could generate a list of candidate stands that may be selected for silvicultural treatment or evaluated in management experiments. For example, a spectral “signature” can be generated via GIS analysis of known owl nesting sites that are mapped on Landsat or other satellite imagery. Then the GIS might be used to locate new, unsurveyed sites that have the same spectral signature, which would be predicted to contain nesting pairs. “Ground-truthing” by checking those sites for owls might lead to a reliable and relatively inexpensive mode for an indirect owl “census” in such habitats. The GIS also could help in testing and refining the habitat capability model described in the FS’s Final Supplemental Environmental Impact Statement (USDA 1988, Vol. 2: B21-22).

Berry (1987b) discussed a fundamental mathematical approach to GIS analyses that treats entire maps (landscapes) as variables. The set of analytical procedures for processing mapped data, or spatial statistics, forms a mathematical structure analogous to traditional statistics and algebra. Spatial statistics characterize the geographic pattern or distribution of mapped data by describing spatial variation, instead of distilling data by using central-tendency statistics. Information from traditional and spatial statistics can be combined for interpretations of information from GISs.

Computerized GIS analyses force users to consider carefully the scale at which the data being processed apply, and to examine carefully the structure of models, such as spotted owl habitat capability models or viability models. These processes enable administrators to understand more fully the analytical process, make comments to analysts on model weightings (such as juvenile dispersal distance or habitat capability ratings), or identify erroneous assumptions in models being applied.

Appendix R: Adaptive Management

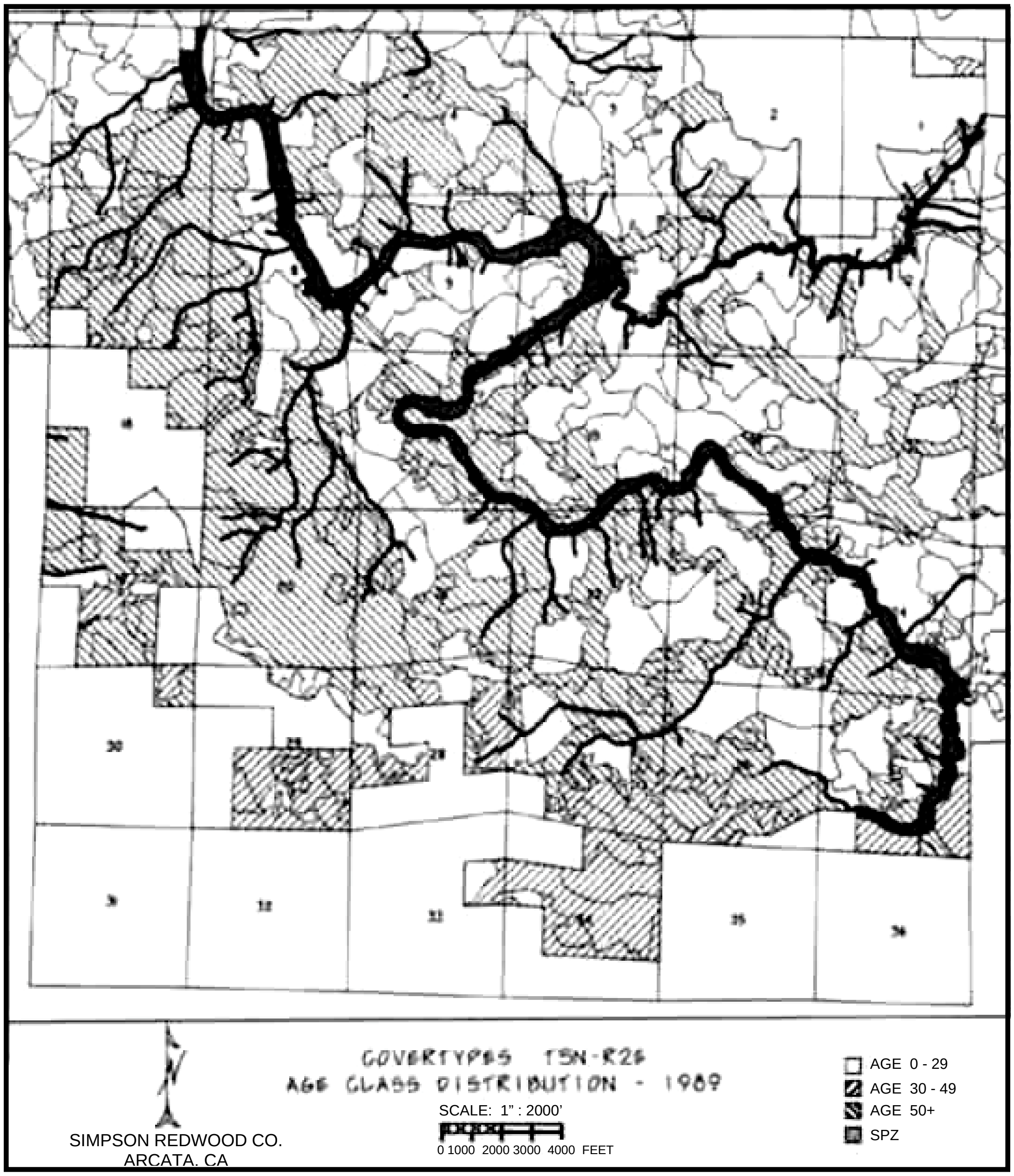

Figure R2—Forest stands by age-class, redwood forest type in northern California. 1989. Courtesy of Simpson Redwood co,. Arcata.

Geographic information system technology may provide a tool for scheduling silvicultural treatments in areas that are currently occupied by northern spotted owls or may be occupied in the future. To illustrate the possibility for a GIS to aid in developing a schedule of timber harvests that results in suitable habitat over time, we show a GIS-generated cover-type map for three age-classes of coastal redwood forest in northern California (fig. R2). This particular tract of land, including about 18,400 acres that were logged completely and burned after the turn of the 20th century, was known to contain more than 25 spotted owls in 1989, including several pairs observed with fledglings (Diller 1989).

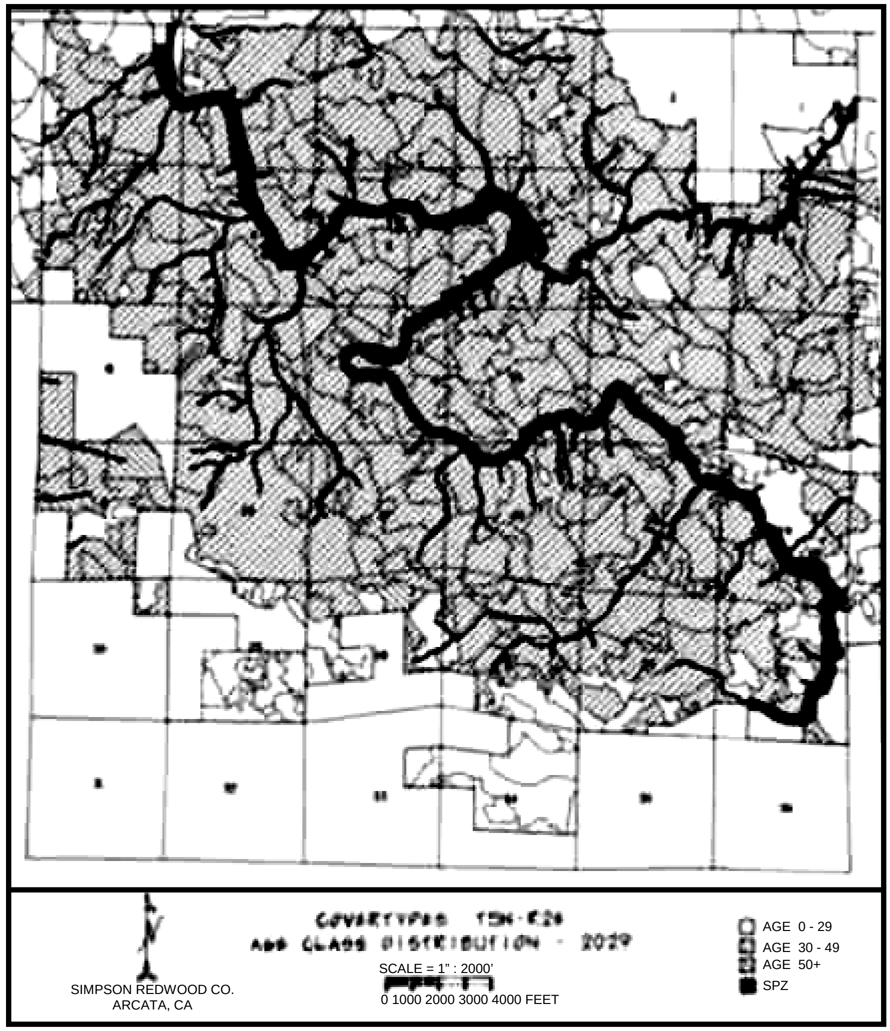

Figure R3—GIS-simulated forest stands in fig. R2 by age-class in the year 2029, redwood forest type in northern California. Courtesy of Simpson Redwood Co., Arcata.

Given a set of simplified assumptions, the GIS-simulated forest conditions for the same landscape in 2029 (fig. R3) and 2049 (fig. R4). For illustration only, the assumptions that were used to determine a particular stand’s age-class included:

- Stands 59 years old in 1989 are harvested in 1990. Such stands will be 19 years old in 2009 and 39 years old in 2029.
- Stands are harvested at age 60 and regeneration occurs without delay. Thus, if a stand is harvested in 2000, the subsequent stand is 1 year old in 2001.
- If an area is classified as nonforest in 1989, it is expected to be nonforest in 2029 and 2049.

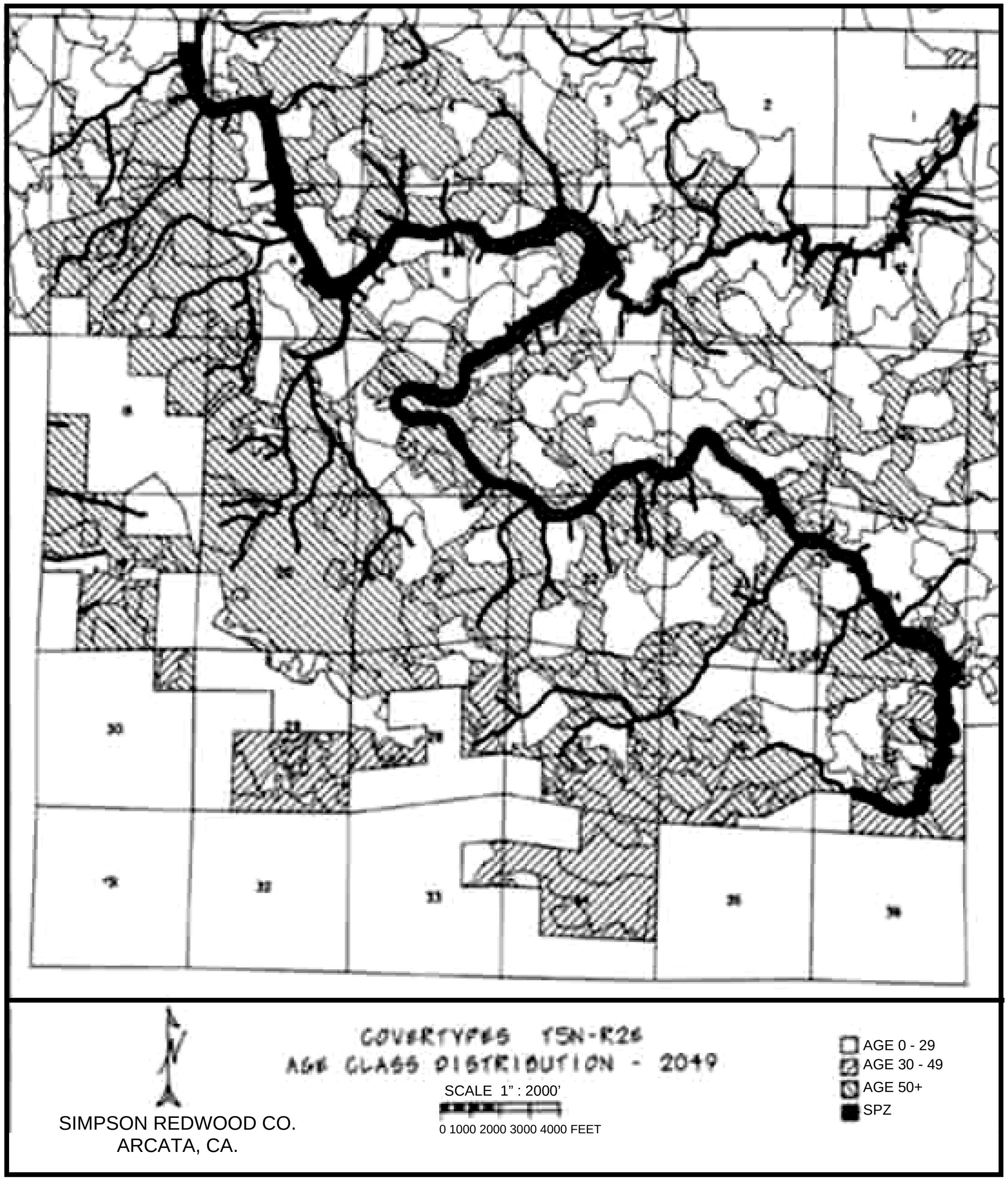

Figure R4—GIS-sirnulated forest stands in fig. R2 by age-class in the year 2049, redwood forest type in northern California. Courtesy of Simpson Redwood Co., Arcata.

Note that the assumptions described above are highly simplified and do not represent any real or planned future situation because the simulation was not constrained by management or other considerations. These scenarios would never occur exactly as depicted, and they represent minimal estimates of forest. They simply illustrate the capability of GISs for simulating future landscapes, and possibly spotted owl habitat, on the basis of a hypothesized set of management plans.

Table R3—Example of GIS-simulations for acreage of forest by age-class (years), given a set of assumptions on harvesting and regeneration in coastal redwood forest in northern California

Year	SPZ[a] acres	%	Non[b] acres	%	0-29 acres	%	30-49 acres	%	50+ acres	%
1989	1343	8.2	1515	9.2	5387	32.8	995	6.1	7167	43.7
1999	1343	8.2	1515	9.2	12502	76.2	679	4.1	368	2.2
2009	1343	8.2	1515	9.2	12733	77.7	188	1.1	627	3.8
2019	1343	8.2	1515	9.2	8251	50.3	5246	32.0	52	0.3
2029	1343	8.2	1515	9.2	1047	6.4	12366	75.4	136	0.8
2039	1343	8.2	1515	9.2	815	5.0	7623	46.5	5110	31.1
2049	1343	8.2	1515	9.2	5298	32.3	995	6.1	7256	44.2

[a] Streamside protection zone.
[b] Nonforested acres.

Because the simulation assumed all stands >59 years old were harvested in 1990, spotted owls would be predicted to be absent for more than a decade or so. The simulated landscape for the year 2029 (fig. R3) contains significant acreage (>12,000 acres) in the 30- to 49-year-old class, which should be useful as foraging habitat for spotted owls in redwood forests. By 2029, the simulated landscape night already have some owls that recognized the area, assuming that potential nest sites would be retained in streamside-management zones and other areas with constraints on timber harvest. By the year 2049, the simulated area (fig. R4) would be predicted to have over 7000 acres of habitat (table R3) that ostensibly is suitable for several pairs of owls, based on real data from 1989.

If a landscape management situation like this one were actually part of a strategy for scheduling timber harvests in areas to be occupied by spotted owls, several other topics would have to be incorporated. They include the requirement of a refuge, such as an HCA, to provide dispersing juveniles for recognizing the area when it again contains suitable habitat. Also, details of stand conditions would be needed, perhaps obtained by using stand-development models coupled with ground-truthed information. Furthermore, knowledge of the proportion of suitable habitat required within a specified landscape area would be needed (Mickey, pers. comm.). And information is needed on spotted owl responses to rapidly changing landscapes. Ultimately, the value to long-term population persistence of landscapes that alternatively are suitable, marginally suitable, or unsuitable would have to be determined, in association with nearby refugia.

Thus, GIS technology provides a tool that may result in more ecologically based policy decisions because of better linkages between researchers and managers. Working GISs are, or soon will be, available at most National Forests, BLM Districts, and State wildlife and land management agencies. Numerous private industrial organizations already have operational GISs. In fact, spotted owl habitat has been analyzed using Landsat imagery in numerous areas.

Appendix R: Adaptive Management

We believe that GISs provide the best available technology for integrating monitoring and research, and for increasing communication among managers, researchers, and biologists. Moreover, GISs appear capable of aiding interpretations that can lead to needed or justifiable adjustments in the conservation strategy. The coordination of the database for spotted owls, including GIS capabilities, requires active participation by public and private organizations.

Conceptual Basis for Reviewing the Conservation Plan

An objective basis must be developed to evaluate the results of management experiments and monitoring so as to signify when a review of the conservation strategy is warranted and to modify it appropriately when necessary or desirable. Feedback from monitoring and research to management policy requires articulation of expected responses to our initially prescribed landscape scenario and alternative management hypotheses that can be tested. Risk analysis procedures may be integrated with the adaptive management approach for assessing the efficacy of the conservation strategy, and determining the potential for change (Marcot 1986).

The basis for review and modification could include a series of “if-then” statements associated with predictions from each management strategy that is tested (fig. R5). A rule set should be identified that describes how to interpret the results of field comparisons of alternative hypotheses at each scale. Establishing such a rule set requires evaluation criteria for important biological parameters, and for the amount of change that will modify management at each scale.

Specifically, the rule set might include: determine how observed trends compare to expected trends in important life-history parameters; state inappropriate and appropriate statistical comparisons, interpretations, assumptions, and inferences; decide at what point, and how, observed trends trigger review of the conservation strategy, study designs, specific management direction, or the objectives and intent of the management direction. This process may entail identifying thresholds or ranges of values of parameters and their trends.

The adaptive management program should develop explicit criteria for measuring vital life-history parameters that would result in changes of management practices to ameliorate undesired amounts, rates, or trends, or conversely, that would allow relaxation of constraints. What those levels should be is not immediately clear. Research appears necessary to develop the early warning signals that could indicate that changes are needed—say increased protection (for example, unusual adult turnover rate, or unusually low mate fidelity). The potential for using the results of monitoring and research to determine that alternative management is indicated should identify the scale at which such changes may take place.

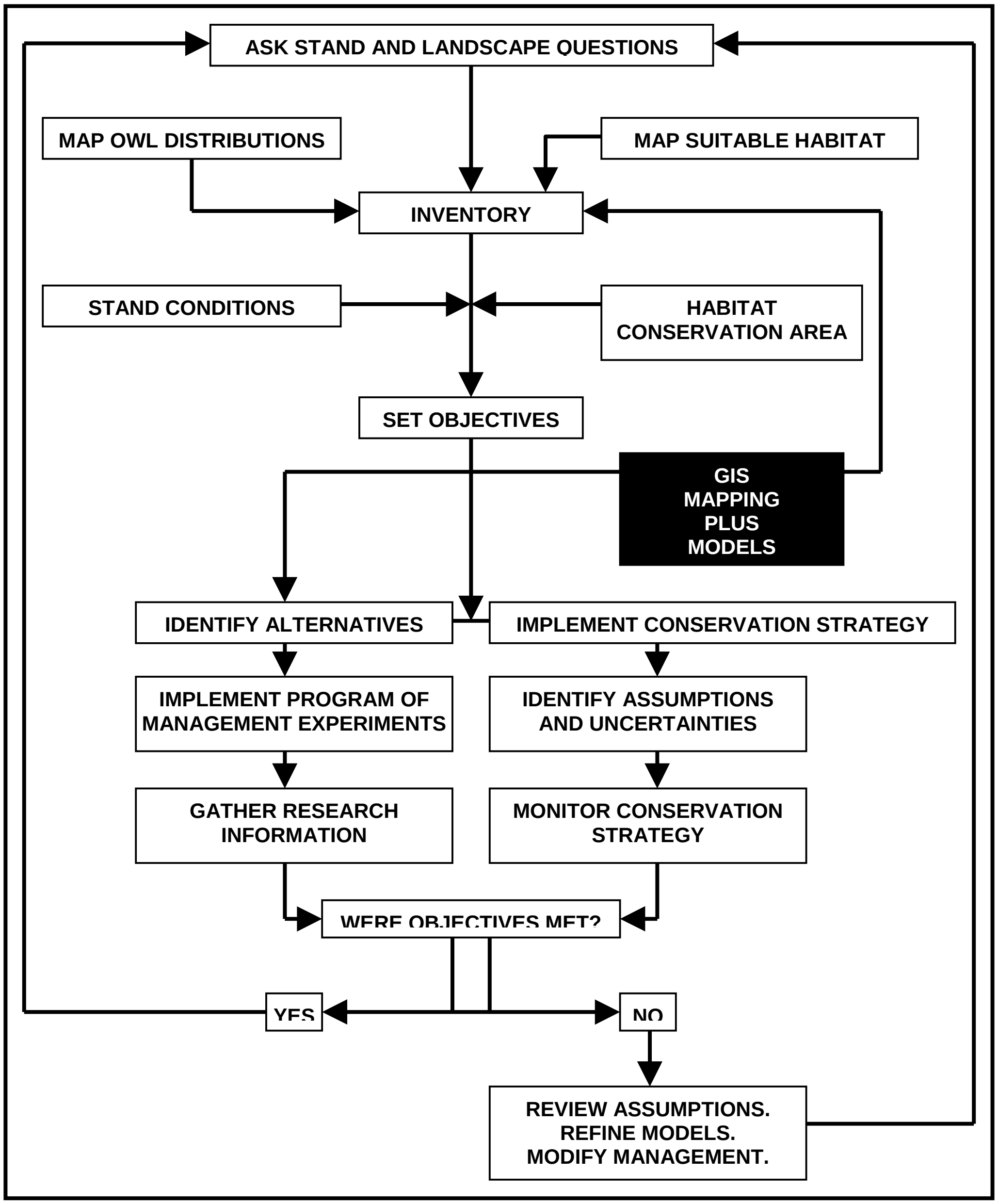

Figure R5—Conceptual basis far adaptive management to modify the conservation strategy through management, experiments and monitoring.

Finally, we recommend that agencies responsible for managing northern spotted owls develop an interagency technical committee that would develop protocols for monitoring, and set priorities for research, as set forth herein and in accordance with the conservation strategy. This group would manage the database for spotted owls, including coordinating GIS-based information. Finally, this committee would be responsible for ensuring the recommended strategy is implemented fully, and would make recommendations on appropriate modifications to the conservation strategy. The interagency committee should be supervised by a program leader employed by one of the Federal agencies. We suggest that personnel serving on the technical committee should be selected from the respective State and Federal agencies, interest groups, and from the forest products industry.

Appendix R: Adaptive Management

Summary

Wildlife management has no final truth—management consists of successive approximations based on knowledge and experience. We believe we have identified a safe course to pursue, holding no unrealistic expectations that the truth will come easily. The adaptive program that we propose allows interested groups to work together in framing the questions to be asked, conducting the management experiments, and interpreting results in ways that may be applied in management. We believe the program could become a formula for a persistent owl population and a sustained yield of forest products.

We recommend an adaptive management program that combines research and monitoring. An adaptive management program can rapidly verify that the conservation strategy maintains a well-distributed, persistent population of northern spotted owls, and can attempt to resolve the conflict between preserving and managing spotted owl habitats. The program can evaluate available landscape strategies and potential forest stand treatments that might improve habitat and distribution of spotted owls.

Research and monitoring must be well coordinated to evaluate the conservation strategy and alternative options. Monitoring will gather habitat and demographic information, including banding all spotted owls in selected units that include two HCAs and intervening forests. The research program uses scientifically driven management experiments to test the predictions and assumptions of the conservation strategy and alternative landscape options and stand treatments. Subsequent management direction may increase protection or relax constraints on timber harvest, based on experience gained from the management experiments. For the next several years, significant options will exist to increase protection if such increases are determined to be necessary.

Because forestry practices accidentally resulted in habitats in which owls breed successfully in some areas, suitable habitat probably can result from silvicultural design. Therefore, the Committee recommends gathering as much information as possible from owl pairs that will be influenced by timber harvests in sites between HCAs. Information thus gained may lead to new treatments that maintain or create owl habitat silviculturally.

Silvicultural modifications may include producing multilayered stands and leaving structures such as large trees, snags, and downed woody debris. Over time, timber harvests may be scheduled in HCAs. Allowing significant timber harvesting in HCAs logically would follow from data that conclusively showed the owl population was stable or increasing, and after verifying a positive owl response to stands that have been treated silviculturally.

The Committee recommends the development and use of a GIS that is linked with computer programs for predicting forest growth and yield and also for predicting the forest's capacity to support pairs of owls. A GIS can simulate and analyze changes in forest stands and landscapes in terms of owl habitat, expanding the ability to plan management experiments or schedule stand treatments with owls in mind. The GIS would enable decision makers to understand and comment on the analytical process, resulting in an ecologically based policy because of better linkages between researchers and managers.

Altogether, the adaptive management program must determine the aggregate value, in terms of spotted owl persistence of HCAs, individual- and multiple-pair areas, and managed forests with suitable habitat. The primary challenge for the immediate future is to develop a quantified process for using the results of the adaptive management program to determine the necessity for or provide justification to review, and perhaps modify, the conservation strategy.

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S

Silvicultural Experiments for Habitat Management

Introduction

Silviculturists, foresters, and wildlife biologists must begin to experiment with new approaches to forest management to determine if suitable habitat for spotted owls can be created over time or retained at the same time that commodity values are extracted from stands in managed forests. We believe the desired stand condition to be produced by silvicultural design includes multilayered and relatively closed canopies, mixed species composition dominated by large trees, numerous large snags, and considerable amounts of large logs and other woody debris on the ground (Forsman et al. 1984, Gutiérrez et al. 1984, Irwin et al. 1989, LaHaye 1988). Large trees with broken tops, secondary crowns, large limbs, hollow boles, and clusters of limbs infected by dwarf mistletoe should be created or maintained, either in clumps or as scattered individuals within the stand.

We do not yet know if creating these structural conditions in stands will retain spotted owls and allow them to breed successfully. Some evidence suggests, however, that historical methods of logging, which left numerous remnant trees or patches of trees and large amounts of woody debris, could produce suitable habitat in a much shorter period than can the contemporary emphasis on clearcutting and burning (Irwin 1989 unpubl.) We are aware of only limited evidence that indicates clearcutting and burning methods may create suitable owl habitat in less than 100 years—the highly productive coastal redwood zone of northern California (Diller 1989, Pious 1989, Irwin et al. 1989 unpubl., see also appendix G).

Here, we present a first approximation of the silvicultural systems and treatments that might be used to produce the appropriate stand conditions in which spotted owls can breed successfully. We hypothesize that spotted owl habitat can be developed through silvicultural systems and treatments. The need is urgent to develop operational experiments specific to each physiographic province to test this hypothesis, as described in appendix R. For example, experiments designed to show how prey species respond to forest understory manipulation will likely target woodrats in California and southern Oregon, and flying squirrels in Washington and northwestern Oregon.

We focused on the forest stand because it is the unit for which silvicultural prescriptions are developed and to which treatments are applied. Although silvicultural prescriptions are developed stand by stand, spotted owl habitat is composed of an aggregation of many stands that comprise a landscape. Given the variation of site conditions and stand structure across a landscape, no single silvicultural system will suffice. Therefore, silvicultural prescriptions need to be developed after careful thought to site-specific conditions, stand structure, and the appropriate arrangement of stands across a landscape as large as the home range for a pair of owls. Such prescriptions for landscapes require knowledge of how spotted owls respond to the mosaic of stands with varying conditions over space and time.

Appendix S: Silviculture

Spotted owls occur in a variety of forest types. Each type has a somewhat particular species composition of trees, shrubs, and forbs, and other environmental variables such as windthrow, root disease, fire history, and microclimates that affect the practice of silviculture, the rate of stand development, and the spotted owl response. The rate of development of structures suitable for owl habitat will depend on both the current stand structure and the site quality or rates of growth. We do not attempt, therefore, to offer specific prescriptions for each forest type. Instead, we provide some general approaches that would be applicable to most forest types.

Importance and Role of Silviculture

Forest stands are dynamic, changing with time as individual trees and other plants are established, grow, and die. Such changes, and opportunities to influence them, must be considered in long-term plans to provide spotted owl habitat. The rate and significance of changes vary with stand age and condition. Young stands become more dense as trees grow larger in diameter and height (McArdle et al. 1961). Very old stands may make no net growth, but species differences in mortality rates and regeneration are substantial (DeBell and Franklin 1987). Thus, with time, some suitable habitat will deteriorate and other stands may develop into suitable habitat. Such natural patterns of development vary with forest type. Silvicultural knowledge can help predict the rate and direction of stand changes. The need and opportunity for habitat manipulation vary with forest type, stand age, and condition.

Current silvicultural manipulations that might be used in experimental designs are:

- **Enhancing suitable or marginally suitable habitat—**For example, understory thickets can be thinned to test if such activities will increase prey numbers and owl use in those areas. Downed trees and snags can be created to see if prey density can be increased.

- **Maintaining suitable habitat within a managed, multiple-use forest—**Harvest systems that provide for continuous production of spotted owl habitat and wood products at the same time and place can be tested.

- **Accelerating the development or creation of habitat in stands now unsuitable for spotted owls—**Sometimes, natural trends toward developing suitable habitat can be accelerated silviculturally. In other instances, habitat is unlikely to develop naturally under current management, unless silvicultural activities are designed to create it.

Silvicultural Treatments and Stand Development Patterns

We describe two basic stand structures, define major silvicultural treatments, and show likely development patterns for these structures (see figure S1). The major options are cross-referenced to stand diagrams, using a number-letter convention. These diagrams represent a range of stand conditions or structures that could be developed from single-layered or multilayered stands. The purpose of these diagrams is to show patterns of stand structural development that are likely to apply in most forest types.

Single-canopy structure—Single-canopy structure generally occurs in even-aged, single-species stands or stands of two or more species with similar growth patterns. A common example can be found in single-species stands of Douglas-fir or western hemlock.

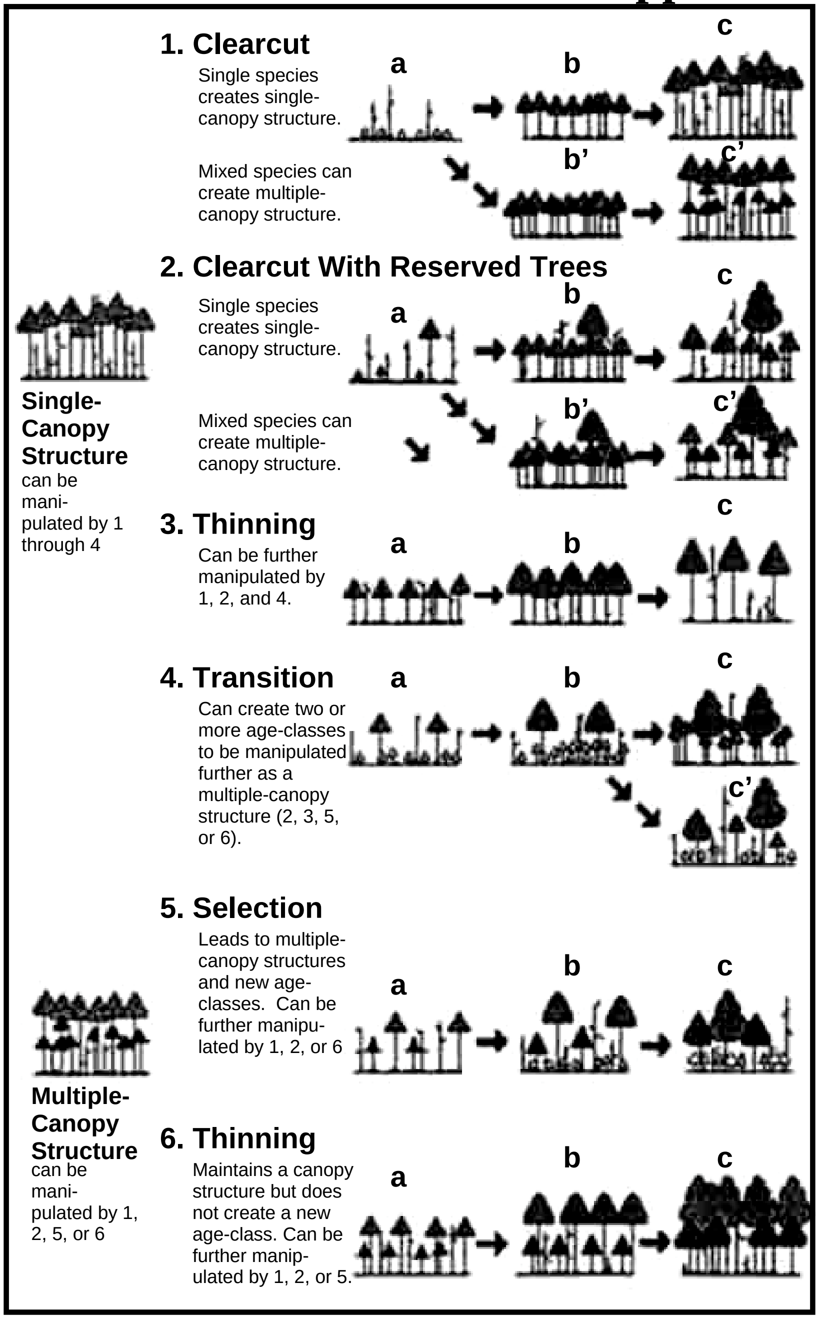

Figure S1—Generalized silvicultural approaches for manipulating forest structure.

Such stands, with crowns of all trees in the same general stratum, can occur at all ages. Although stands of this type are characteristically uniform, trees can differ widely in vigor and susceptibility to insects and diseases.

Multiple-canopy structure—Multiple-canopy structure can occur in both even-aged and uneven-aged stands. It is commonly found in even-aged stands where one species overtops the others and forms two or more canopy layers. Stands that are truly uneven-aged look superficially similar but have differing histories.

Appendix S: Silviculture

Silvicultural treatments—Both the single-canopy and the multiple-canopy structures can occur within a wide range of stand ages. Each structure can be manipulated in a variety of ways to determine if spotted owl habitat can be provided during portions of a rotation.

A wide range of treatments can be applied to a stand, depending on its condition and the desired objectives. Common examples include site preparation, natural or artificial regeneration, weed control, thinning, fertilization, pruning, genetic improvement, creating snags and logs, and regeneration cutting. Some of these operations can accelerate individual tree growth and shorten the time required to reach a desired structure. Other treatments can prolong the time during which a stand produces desirable habitat.

Single-Canopy Structure

1. **Clearcut**—All trees are felled, and a relatively uniform, even-aged stand develops. Often, particularly on public lands, snags are retained or created from living trees.

   a. The old stand is removed and a new stand is initiated.

   b,c. The stand develops with a relatively uniform canopy and contains species with similar growth patterns. Such conditions do not appear to be favorable habitat for northern spotted owls.

   b',c'. If the stand is regenerated with species of differing growth patterns, it may develop a multiple-canopy structure (Oliver 1980).

2. **Even-Aged Management With Reserved Trees**—Trees left after clearcutting (reserved trees) are physically stable, windfirm, vigorous enough to survive release, not in overly exposed areas, and expected to live for a substantial period. We need to test the effects of both "healthy" and "decadent" trees on spotted owl habitat and the development of the new stand.

   a. Most trees are harvested, but some dominant and codominant trees, as well as snags and logs, are retained. The practice of leaving reserved trees in clumps or well distributed throughout the stand should be tested.

   b. The juvenile stand may be thinned to maintain tree vigor and allow trees to grow faster. The hypothesis that thinning will increase spotted owl use should be tested. The young age-class can develop a single-canopy structure; but if more than one species regenerates, the stand may develop a multiple-canopy structure (panels 2b',c').

   c. As the stand matures, snags can be created and the stand thinned to obtain revenue. We would expect this treatment to increase growth and maintain stability and vigor. Some reserved trees may be intentionally killed to create large snags and prevent suppression of the lower stratum.

3. **Thinning**—Thinning is suitable where dominant trees are physically stable and windfirm, and the stand is not in an area exposed to extreme winds. Thinning needs to be tested to determine what role, if any, it may have where stands are managed on long rotations to attain spotted owl habitat. Thinning has been shown to maintain stand vigor and stability, produce large trees, increase timber values, and initiate the development of understory trees; however, its application to spotted owl management must be evaluated. A variety of stand densities should be evaluated. Stands with this structure can be manipulated by another system at any time (panels 1, 2, or 4).

   a. intermediate and suppressed trees are either killed to create snags or harvested commercially. Dominant and codominant trees are spaced widely to allow them to grow longer and maintain stability. Some dominant and codominant trees may be killed and left standing to create snags, or felled to provide large woody debris.

   b. The remaining trees grow larger, and their dense crowns tend to prevent a new age-class from developing.

   a. The stand may be thinned again to maintain stability, growth, and vigor. Larger snags and logs can be created.

4. **Transition**—Transition is a special technique that is applicable where the objective is to move from a single-canopy structure to a multiple-canopy structure. It is a suitable technique where trees to be left behind are physically stable, windfirm, vigorous enough to survive release, and not in exposed areas. In addition, the overstory trees should be evaluated both in terms of their effect on the understory and their suitability for habitat. Decadent trees may provide desirable habitat; however, they could sometimes adversely affect understory development.

   a. Most trees are harvested. Snags are created or retained from the previous stand, along with some large logs. Scattered dominant and codominant trees are left, and a new stand grows beneath them after planting or natural regeneration. This young stand may be overly dense, and thinning may be needed to maintain vigor.

   b. As the new age-class develops, managed density may become increasingly important. If trees are crowded within the same age-class or crown layer, thinning may be needed to maintain growth and vigor. Also, if the residual overstory excessively shades the younger age-class, some older trees may be harvested or killed to create snags.

   c. The stand can be maintained as two age-classes by thinning the overstory and understory lightly. Further manipulation would follow the processes shown in panels 2, 3, 5, or 6.

   c'. More age-classes can be created by thinning the overstory and understory heavily. Further manipulation would follow panels 2, 3, 5, or 6.

Appendix S: Silviculture

Multiple-Canopy Structure

Stands with multiple canopies can develop from several conditions:

Logging or natural disturbances that remove the least vigorous trees but leave more vigorous and healthy trees. Under these conditions, a vigorous new canopy can develop below the residual stand where densities have been reduced adequately.

“High-grading” or selective logging. Past logging in some areas has degraded residual stands by leaving diseased or weakened trees with little growth potential. This approach has created stands that are now providing spotted owl habitat in portions of the range. Many of these stands have poor long-range stability and growth potential. Where these stands have not been excessively degraded, opportunities exist for retaining healthy dominant and codominant trees of suitable species.

Mixed species, even-aged stands that develop after major (stand-replacing) disturbances can form multiple-canopy strata if the different species grow at different rates.

1. **Selection—**Selection follows the same general sequences described in the transition method.

2. **Thinning—**Thinning is suitable where trees to be left are physically stable, windfirm, vigorous enough to survive release, and not in exposed areas. Trees badly infected with dwarfmistletoe may not be suitable because they can be weakened, break or die, or infect much of the younger age-classes.

   a. Intermediate and suppressed trees of each canopy layer are killed or removed, and dominants and codominants are spaced to allow them to grow larger and maintain stability. Some trees can be used to produce snags or downed woody debris.

   b. Remaining trees grow larger, and increasing density tends to exclude the development of a new age-class.

   a. The stand may be thinned again and larger snags created and large logs left, allowing the stand to maintain stability and grow more vigorously. The stand could be further manipulated by clearcutting, even-aged management with reserved trees, or selection systems (panels 1, 2, or 5).

Implementation

Implementing silvicultural systems to provide spotted owl habitat will require considerable thought and skill. Stands with multiple layers will need careful diagnosis and prescription to determine treatment response. Growth models for mixed species and multilayered stands are not generally available to help with this assessment. Harvest methods will be of particular concern, especially on steep slopes. Creating openings and releasing trees from above in multilayered stands has been done successfully small, well-administered operations, but extending these methods on a large scale must be carefully considered. Safety, increased cost, and the need for close supervision are major concerns. Experienced silviculturists, wildlife biologists, and other specialists must provide time and resources for careful analysis, implementing prescriptions, and monitoring treatments. Managing for these complex structures cannot be by such methods as “loggers choice” nor can implementing the techniques be left to inexperienced, unskilled personnel.

From the perspective of silvicultural knowledge, most of the techniques we described could be used now, but to make the step from hypothesis to action, we believe several steps are needed:

Spotted owl habitat descriptions need to be more precise. Habitats could be unique to certain plant communities, physiographic regions, or major forest types. The silviculturist and wildlife ecologist need to jointly develop quantitative and qualitative descriptions of desired forest conditions for spotted owl habitat.

Silvicultural methods and systems need to be refined. We see much of this activity as an extension of the thoughts presented in this paper, an extension of our suggested methodologies and applications.

Silviculturists need specific training to recognize spotted owl habitat attributes and methods for developing them.

Technology for linking stand-scale and landscape-scale analysis and treatment must be refined.

We need to look closely at the quality of habitat we are attempting to create with new silvicultural systems. A long-term view cannot be focused on providing minimum requirements for spotted owls while maximizing revenue. We need to focus on creating superior habitat in HCAs and less than optimum, yet biologically functional habitat in the forest matrix. Currently, we believe the best way to create superior habitat for spotted owls is to develop stand characteristics that mimic as closely as possible current old-growth conditions. Our long-term goal is to return spotted owls to the general forest matrix and no longer require HCAs with defined boundaries. We will only be able to attain this goal when silvicultural systems are applied in a way that tests the quality and quantity of owl habitat that can be produced.

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T

Viability Risk Assessment

Maintaining Population Viability

The chance or likelihood that a wildlife population will continue to exist in an area is known as its viability (Samson et al. 1985, Schonewald-Cox et al.1983, Shaffer 1983). A population with high viability has a high likelihood of persistence. Maintaining the viability of spotted owl populations entails ensuring adequate amounts and distributions of habitat for all life needs. Populations should be able to interact and should be of sufficient size that risks of declines are very low over a period of at least a century or longer (Conner 1988, Shaffer 1981).

The ultimate goal of maintaining population viability is to provide for long-term genetic evolution, on the order of thousands or tens of thousands of generations (Barrowclough 1980, Emigh and Pollak 1979). At this extreme time scale, we are scarcely able to conceive the many factors that influence evolution, and are unable to predict long-term and large-scale changes effected by such influences as climate (Graham 1988), vegetation and habitats (Quinn 1989), and species interactions. Our focus under this strategy, therefore, is on the order of 6 to 12 generations (50 to 100 years) for a long-lived species such as the spotted owl.

In general, smaller and more isolated populations are much more susceptible to higher viability risks than are larger, interacting populations (Iwasa and Mochizuki 1988). Thus, viability is better ensured when populations—and habitats for breeding, feeding, dispersal, and other life needs—occur in widely distributed, contiguous patterns (Shaffer and Samson 1985; also, for example, see the island archipelago model of Harris 1983).

Viable spotted owl populations should be able to persist despite threats to their continued existence. Specific objectives for maintaining population viability include providing habitats that are

- Of high quality and of sufficient size and proximity to ensure high rates of re-productive pair occupancy:
- Spaced closely enough and of sufficient size to ensure high probabilities of being locally recolonized (Brown and Kodric-Brown 1977); and
- Distributed so as to ensure that individuals interact among geographic locations, providing for populations that do not become demographically isolated (Hastings and Wolin 1989).

Most of these factors are addressed in appendices M, N, O, and P. These appendices should be consulted for explanations of how guidelines for HCAs deal with some of these viability objectives.

Appendix T: Risk Assessment

The conservation strategy provides for the following viability objectives. First, large blocks (HCAs) of high-quality habitat sufficient for holding at least 20 reproductive spotted owl pairs meet the first two viability objectives, ensuring occupancy and local recolonization. Such blocks need to be large enough to ensure very high occupancy rates by reproductive pairs over time. Block occupancy is expected to remain high when blocks are large and of high habitat quality, or when recolonization rates are high, or both. Local pair densities or comparison with the size of the annual home ranges of spotted owl pairs can help verify the size of blocks needed (appendix I). Large blocks, as suggested by this conservation strategy, would be large enough to provide locally high densities and would provide for at least median home-range sizes. Contiguous habitat within such blocks would help avoid adverse results from habitat fragmentation (Wilcove 1987) and edge effects (Harris 1988). It would also provide forest interior conditions, and increase the likelihood of successful dispersal (appendices M and P).

Large blocks of habitats (HCAs), distributed at generally regular intervals across geographic and elevational gradients and throughout the range of the subspecies, meet the third objective. The conservation strategy calls for spacing HCAs at distances well within the dispersal capacities of most juvenile spotted owls. This spacing helps ensure that a habitat block would be recolonized if its population of owls disappears, and also helps ensure broad distribution across a full range of habitat qualities.

Empirical studies of juvenile spotted owls occurred in landscapes offering at least some degree of suitable roosting and travel conditions. Use of observed dispersal distances to plan spacing among HCAs is most appropriate when the landscape between HCAs matches that in the studies (that is, when the intervening landscape offers some degree of suitable roosting and travel conditions). The conservation strategy calls for such habitat to be provided between the HCAs in forested habitat reserved for allocations other than for spotted owls, including streamside and visual corridors, older forest management areas for other wildlife species such as pine marten and pileated woodpeckers, retention of older forest patches centered on known owl nest sites, and some lands unsuited for timber production (appendices P and Q). In addition, the 50-11-40 rule (appendix Q) stipulates that nonreserved lands between HCAs be managed to maintain forest conditions that are useful to dispersing owls.

Viability Effects

Many factors can affect population viability (Soulé 1986, Soulé and Wilcox 1980, Wilcox 1986). Many of these factors are common or normal for most wildlife populations. Some, taken alone, may have a positive impact, such as local increases in prey densities. Of concern to us are factors that can operate individually or together to cause local or widespread decline, especially in areas where low densities or fragmented populations occur. Such declines may ultimately result in the local elimination of the owl, or lead to extinction.

Appendix T: Risk Assessment

The following conditions of environments, habitats, or populations interact to affect viability:

Environmental conditions

- Environmental variation—which results in low survival and reproductive rates—such as fluctuations in prey densities or periods of harsh weather.
- Environmental catastrophes—which result in direct habitat loss, population reduction, or isolation—such as wildfire, windstorms, and volcanoes.
- Local increases in other species, especially predators, competitors, parasites, and disease.

Habitat conditions

- Systematic habitat loss—such as the widespread and rapid conversion of old forests to young forests—by natural occurrences and human activities.
- Forest stand fragmentation—of owl habitat at both local or regional scales—such as from logging activities (principally clearcutting forest stands).
- Connectivity loss—resulting in uneven distribution of spotted owl habitat across physiographic provinces—such as from different patterns of land ownership.

Population conditions

- Random variation in survival and fecundity among individuals within small, isolated populations.
- Loss of genetic variation or length of time in a genetic bottleneck, resulting in reduced fecundity and adaptability, and increased mortality rates, especially in small, isolated populations.

Elements of population viability are displayed in table T1. Specifically listed are the principal factors potentially affecting spotted owl populations, how those factors put spotted owl populations at risk of decline or local extinction, references to conservation strategy guidelines designed to reduce risks, and proposed monitoring and research activities that would reduce scientific uncertainty and aid in higher likelihoods of population viability.

Designing a Conservation Plan for Population Viability

Although risk factors in Table T1 are listed as independent elements, they often compound and interact to create greater degrees of risk than when taken separately. Habitat fragmentation in a watershed, for example, could cause local reproductive success to decline. This decline would reduce the numbers of dispersing juveniles across a landscape, which in turn might cause demographic isolation of owls in parts of its range. Such isolation could increase the likelihood that local populations would decline or become extinct, as a result of environmental variation. Thus, in this example, one factor—habitat fragmentation—Could cause greater risk to viability from another factor—environmental variation.

Table T1—Factors influencing tong-term persistence of well-distributed spotted owl populations, potential risks to viability from each factor, elements of the conservation-plan standards and guidelines designed to reduce those risks, and monitoring and research activities helpful for reducing scientific uncertainties for each risk area

Viability factor	Potential risks	Pertinent standards and guidelines for reducing risk	Monitoring and research topics
ENVIRONMENTAL CONDITIONS			
Variation in environmental Conditions	Periods of low survival and low recruitment interchange; populations of large size to withstand temporary or local declines	Populations distributed throughout the range for associations; correlations of owl productivity with such factors as prey abundance and weather	Prey density, availability, and habitat
Catastrophes	Direct loss of habitat and populations	Distribution of HCAs within and among provinces for recolonization and for lowering odds of large-scale habitat loss	Descriptions of type, frequency, duration, extent, and severity of catastrophes as affecting habitat
Other species	Direct predation; competitive exclusion from habitats; ultimate source of mortality from parasites and disease	Dispersion of HCAs, reducing risks from parasites and disease; blocking of large habitat areas in HCAs, possibly reducing risks from great horned and barred owls, assurance of more natural habitat likely to include conditions needed to elude predators (for example, multilayered canopies)	Barred owl range expansion; great horned owl habitat use; effects of competition and predation on spotted owl populations
HABITAT CONDITIONS			
Systematic habitat loss	Rapid, short-term declines in local population size	Provision of habitat in HCAs and intervening areas, resulting in Known and controlled changes in Habitat amount, quality, and distribution	Rates of decline of suitable habitat; refined definitions of suitable spotted owl habitat

Table T1—continued

Viability factor	Potential risks	Pertinent standards and guidelines for reducing risk	Monitoring and research topics
HABITAT CONDITIONS Continued			
Habitat fragmentation	Reduction in reproductive success; loss of pairs or individuals; encouragement of adverse environmental and vegetative conditions; attaction of competitors and predators	Blocking of habitat strands into contiguous HCAs to reduce edge and increase forest-interior conditions	Effect of fragmentation on recruitment and habitat occupancy; energetics requirements; effects of edge and canopy structure on forest
Distributional gaps	Demographic isolation of subpopulations, reducing effective population size	Close spacing of HCAs with intervening habitats for linkage; dispersion of habitats across geographic range of the subspecies	Dispersal and colonization dynamics of owls among habitats; role of various habitat structures
POPULATION CONDITIONS			
Demographic variation	Local extinction of small, isolated populations	Provision of high-quality habitat in HCAs large enough for 20+ pairs, shown empirically and through modeling to provide high probability of at least intermediate-range persistence; linkage of populations for local recolonization	Population dynamics, rates of change, population structure within and among habitats
Loss of genetic variation	Reduced survival and fecundity, resulting in demographic delines and local extinctions	Provision of interacting, relatively large effective population sizes	Genetic characteristics of subspecies and potential population isolates

Likewise, components of the conservation strategy are designed to interact as hedges against population declines. The first line of defense against risk to viability is to provide HCAs of sufficient size-—generally with the capability of supporting at least 20 pairs of owls (appendices M and O). This size ensures that such areas remain populated with pairs at least for several generations, even if isolated. The second line of defense is to ensure that habitat within HCAs is as contiguous as possible to enhance recolonization of vacant territories by birds from within the HCA (appendix M). Contiguous, high-quality habitat may also minimize the effects of predators and competitors.

The third line of defense is to space HCAs so as to prevent isolation (appendix P). Guidelines for spacing HCAs help ensure that a reasonable proportion of dispersing individuals should reach other HCAs. Successful dispersal increases the likelihood that HCAs would be occupied for many generations through increasing population size. Larger populations are more resilient to demographic and genetic risk factors.

Next, widely distributing habitats throughout the subspecies' range is a defense against large-scale habitat loss resulting from catastrophic events (appendices N and O). Widespread distribution also helps ensure that large population areas, such as in the Oregon Coast Range and in the northern Washington Cascades, do not become isolated.

Finally, providing dispersal, resting, and foraging habitat in the forest matrix serves several functions: it helps reclaim areas of more severe fragmentation, thereby restoring connectivity within the matrix: and it increases the likelihood that owls interact between HCAs and subpopulations (appendix P). Short-term protection of additional known pairs and perhaps future pairs in problem areas also increases effective population size.

Taken together, the standards and guidelines which underpin the conservation strategy provide strong insurance against viability risk factors. We believe that the recommended strategy provides for a high probability of success over the next 100 years. The probability should be very high for those areas where the primary strategy of 20-pair blocks can be successfully applied.

Areas With Problems of Habitat Distribution

The Committee determined that a viable population of spotted owls could be supported if habitat were distributed within and among HCAs such that those containing at least 20 owl pairs would occur within the dispersal capabilities of the majority of juvenile owls. In some physiographic provinces, however, habitat is currently not available for such a distribution. This lack is typically because of recent timber management activities (mostly mature and old-growth forest harvesting), land ownership patterns, recent disturbances (such as wildfires), and land capability. These areas are identified in table T2, along with the current concerns that exist for these areas.

Table T2—Forest Service assessment of the probability of maintaining viable spotted owl populations by physiographic province in Washington, Oregon, and California (USDA 1988 [a]) for comparison between SOHAs and the assessed probability of success of the HCA strategy (table T5)

Area	Summary of concerns	Viability assessment 50 years	Viability assessment 100 years
WASHINGTON			
Cascade Province (east and west):		Moderate	Low
South Cascades	Local connectivity (fragmentation); low population size	—	—
North Cascades	Low population size and density; local connectivity (habit fragmentation, isolation and distribution); potential competition (barred owls)	—	—
North Cascades/east	Very low population size and density; local connectivity (same as North Cascades); potential competition (barred owls)	—	—
Columbia River Gorge	Demographic connectivity with Oregon	—	—
Olympic Peninsula	Low population size and density; isolation (demographic and genetic); habitat fragmentation and distribution; land-ownership patterns	Moderate	Moderate
Southwest Washington	Scattered pairs observed; lack of habitat (amount, distribution, and fragmentation); land-ownership patterns	(not rated)	
OREGON			
Cascade Province (east and west):	Local connectivity (fragmentation)	High	Moderate
Cascades/east	Low population size and density; local connectivity (fragmentation, isolation, and distribution)	—	—
Columbia River	Demographic connectivity with Washington	—	—
Klamath Province	Local connectivity (fragmentation)	High	Moderate
Coast Range Province:			
Coast Range Area of Special Concern	Low population size and density; local connectivity (same as Cascades/east); land-ownership patterns	High —	Moderate —

Table T2—continued

Area	Summary of concerns	Viability assessment	
CALIFORNIA		50 years	100 years
Klamath Province	Local connectivity (fragmentation)	High	Moderate
South Mendocino NF	Low population size and density; local connectivity (fragmentation, isolation, and distribution); lack of habitat (amount, distribution, and fragmentation)	—	—
Cascade/Modoc Province:		(not rated)	
Shasta/McCloud Region	Very low population size and density; local connectivity (same as south Mendocino); lack of habitat (same as south Mendocino; land-ownership patterns	—	—
North Coast Range Province	Land-ownership patterns	(not rated)	

[a] Rating categories for viability estimates (adapted from USDA 1988)

VERY HIGH (VH): Continued existence of a well-distributed population in the planning area is virtually assured, even if major catastrophic events occur within the population, research finds that the species is less flexible in its habitat needs, or if demographic or genetic factors prove to be more significant than assumed in the analysis.

HIGH (H): Likelihood is high that a well-distributed population will continue to exist in the planning area. Some latitude is allowed for catastrophic events to affect the population or for biological findings that the population is more susceptible to demographic or genetic factors than was assumed in the analysis.

MODERATE (M): Likelihood of continued existence of a well-distributed population in the planning area is moderate. Limited latitude exists for catastrophic events affecting the population or for biological findings that the population is more susceptible to demographic or genetic factors than was assumed in the analysis.

LOW (L): Likelihood of continued existence of a well-distributed population in the planning area is low. Catastrophic, demographic, or genetic factors are likely to cause elimination of the species from parts or all of its geographic range during the period assessed.

VERY LOW (VL): Likelihood of continued existence of a well-distributed population in the planning area is extremely low. Catastrophic, demographic, or genetic factors are highly likely to eliminate the species from parts or all of its geographic range during the period assessed.

In such areas, the distribution, density, and total numbers of spotted owl pairs is lower than desired for maintaining viability. To assist in evaluating these areas, we used the following formula to estimate crude owl-pair density for HCAs located within and between provinces, and for any areas of special concern within provinces:

$$\frac{\text{number of pairs (in HCAs)}}{\text{gross acres (in HCAs)}} \text{ X } 10{,}000 = \text{average density per 10,000 acres.}$$

To estimate crude owl-pair density for the Oregon Coast Range, for example, first calculate the total number of pairs for the HCAs within that area (from appendix Q, table Q5), then calculate the total gross acreage for the same HCAs, and insert those figures into the formula. The result is the crude density.

$$\frac{\text{83 known pairs}}{\text{732,000 gross acres}} \text{ X } 10{,}000 = \text{1.1 pairs per 10,000 acres.}$$

Density is not the best indicator of habitat condition or quality, but it is useful for the purposes of this comparison. For example, the crude density of known spotted owl pairs, in areas of good habitat distribution in the Oregon Cascades, is about 1.5 known pairs per 10,000 acres. In contrast, pair densities in some of the Areas of Special Concern is markedly lower: 0.7 known pairs per 10,000 acres in the Olympic Peninsula HCAs, and 0.7 known pairs per 10,000 acres in the northern Washington Cascade HCAs. Thus, our expectation is that these areas would be subject to a higher degree of risk than those areas with higher densities and with better habitat amounts and distribution. The same comparison can be made between estimated or expected pairs both within and outside of HCAs in any province.

Owl density comparisons between areas with fairly uniform distributions of both suitable habitat and owl numbers, and areas with discontinuous distributions, are misleading. Discrepancies most commonly arise when areas under one ownership are compared to areas with multiple ownership, or when densities are estimated at different spatial scales. For example, in the Shasta/Modoc Area of Special Concern in northern California, owl density is very low because of the patchy distribution of suitable habitat, which results from checkerboard land ownership and different land-use histories. Owl densities within HCAs on FS lands within this region, however, are high (about 1.8 pairs per 10,000 acres). All known pairs in this area are within HCAs and are confined to FS land. As a consequence, owls appear to occur at high densities. The situation appears much less favorable for owl viability, however, considering the relatively small HCA sizes in this area, the distances between them, and the lack of owls and habitat on the intervening lands. This pattern, generally true for all identified Areas of Special Concern, substantially adds to the risk of long-term viability for the spotted owl in these areas.

For similar reasons, the checkerboard land ownership pattern of BLM lands within the range of the owl increases the risk for long-term owl viability In these areas. BLM lands are, nevertheless, extremely important for connectivity between populations of owls in the Cascade, Klamath, and Coast Range provinces in Oregon, and between HCAs in the Coast Range and Klamath provinces in California, for maintaining vIable populations in these areas, and for restoring populations in the Oregon Coast Range.

Existing situations also vary within as well as among provinces because of differences in the amount and distribution of available habitat, and in land ownership. For example, significantly fewer owls and patches of suitable habitat occur in the identified Area of Special Concern in the northern part than in the remainder of the Oregon Coast Range. Owl densities in the Area of Special Concern are 0.8 known pairs per 10,000 acres versus 2.3 pairs per 10,000 acres in the southern pan of the Coast Range. Compare these estimates to the 1.1 pairs per 10,000 acres in calculated above for the whole Coast Range. Similar situations exist in the North Cascades Area of Special Concern in Washington (density of 0.7 pairs per 10,000 acres), the Mendocino Area of Special Concern in California (density of 1.0 pairs per 10,000 acres), and others (see appendices C and Q).

Problem areas—those HCAs with low densities of owls—encounter additional viability threats. Suitable territories in these HCAs are less contiguous. The result is that successful dispersal within HCAs becomes more uncertain, rates of territorial replacement when birds die are lower, and owls spend more time traveling through the surrounding forest matrix (see appendices M and P). These factors collectively contribute to low survival and fecundity rates and to increased viability risks in those areas.

Relative Security from Factors that Could Threaten Population Viability

The combination of low pair densities, low total number of pairs, low numbers of recruits and dispersing owls, and the resulting low dispersal success, results in a substantially higher risk that the HCAs in these areas will not be occupied by reproductive pairs over the long term. We believe that individual, isolated pairs or small numbers of pairs (for example, less than 10, see appendices M, N, and O) in such problem areas have, at best, a low to moderate likelihood of continued existence beyond four or five generations. Occupied sites in many such areas, if not supplied with additional new habitat and with new immigrants, would likely begin to wink out beyond that time.

The methods we used to assess viability risks were independent of those used by the FS in their 1988 Supplemental EIS (USDA 1988). In general, we explored the dynamics of a population experiencing habitat loss and decreases in population number in the context of a spatial simulation model (appendix M). Our analyses allowed us to explore the effect which varying spatial arrangements and suitable habitat amounts would have on owl population dynamics, and its likelihood of persistence. Despite the differences between our analyses, we found some similarities. Both analyses, for example, ‘recognized’ the impossibility, given our current understanding, of assigning quantitative values to risk factors. We adopted a qualitative index for assigning risks to categories, similar to what was used by the FS (USDA 1988; table T2).

Appendix T: Risk Assessment

Previous FS analyses of viability risks assessed a system of individual pair SOHAs, or two- to three-pair clusters of SOHAs (USDA 1988). The informal risk analysis of our conservation strategy assessed, for the most part, the efficacy of at least 20-pair HCAs compared to HCAs providing for many fewer pair territories (appendix M). Because we proposed a strategy that differs significantly from the current SOHA network, we compared the projected number of pairs sustained in both the short and long terms between the SOHA system and this strategy (tables T3 and T4). Little difference appeared in numbers projected over the short term. In the long term, however, the HCA system provides for significantly greater pair numbers. Perhaps of greater importance than increased pair numbers in the HCA system is the greatly increased likelihood of persistence that results from arranging suitable owl territories in contiguous clusters of 20 or more territories (see appendices M, N, and O). In fact, the difference between the strategy we proposed and the probabilities associated with the SOHA system may be greater than we have predicted because we believe that the FS's estimate of the success of the SOHA system was too high.

Table T3—Comparisons of estimated number of pairs to be protected by the SOHA and HCA strategies

		Estimated number of pairs	
Management strategy	Number of sites	Short term	Long term
SOHA Strategy			
Forest Service			
SOHAs	654	506	365
Wilderness		180[a]	180
Bureau of Land Management			
SOHAs	109	97	65
Wilderness		15	15
National Park Service		75	75
SOHA Totals	763	876	739
HCA Strategy			
HCAs (FS, BLM, NPS lands)	157	1465	1759
Areas reserved from timber harvest outside of HCAs[b]		71[a]	71
HCA Totals	157	1536	1820

[a] Assumes pairs in wilderness outside of protection areas (SOHAs or HCAs) will persist, which may be optimistic.
[b] Additional pairs in HCAs on other ownerships, if established, will provide even greater security, especially in Areas of Special Concern.

Table T4—Known pairs outside HCAs but located in Wilderness Areas, National Parks, or otherwise protected areas[a]

Ownership	Number of known pairs
Washington	
Fish and Wildlife Service	1
Forest Service	26
Tribal	5
Oregon	
Forest Service	15
National Park Service	5
Bureau of Land Management	9
State Parks	1
California	
Forest Service	10
Total Pairs	72

[a] Pairs documented in the last 5 years. Data from National Forests, BLM Districts, and other agencies.

We have concluded that the risk to the owl population is significant under a management scenario based on single or one- to three-pair SOHAs (for further discussion on the risk associated with the SOHA system see appendix O). For some areas within the range of the owl, however, we have no choice but to designate HCAs that may support only a few pairs. We recognize the problems inherent in this approach, and have concluded that the long-term risk to such areas is greater than to areas with a preponderance of larger HCAs. The risk in areas augmented by smaller HCAs is less than it would be if only SOHA management were done. The spacing between these areas, the expected quality and contiguity of the Included habitat, and the proximity to larger HCAs results in enhanced opportunities for owl recolonization or for sustained owl occupancy in the small HCAs, thus reducing risk to long-term persistence.

Owl population viability on the Olympic Peninsula was assessed separately from the remainder of the population because of the lack of connectivity between the Peninsula and the Washington Cascades and the Oregon Coast Range. The long-term risks to population viability on the Peninsula would be greatly reduced if HCAs were established on intervening lands, or if those lands were managed to provide for successful dispersal. The Committee believes that the probability of long-term success would be high if the strategy is fully implemented on all lands.

The potential for success of the conservation strategy varies between and within provinces because of the differences in owl numbers, suitable habitat amounts, distances between HCAs, relative isolation, and other factors discussed in this and other appendices. In the Areas of Special Concern, the probability of long-term success may be substantially lower because of their higher risks. Nevertheless, with full implementation of the conservation strategy (table T5), we believe that a high to very high probability of long-term success exists for maintaining population viability for the northern spotted owl through the next 100 years over its current range.

Table T5—Qualitative assessment of the probability of maintaining viable spotted owl populations by physiographic province and Areas of Special Concern in Washington, Oregon, and California: current viability and viability after adoption of the proposed conservation strategy

Area	Recommended strategy	Current Viability[a]	Viability after adoption of conservation strategy[b]	
WASHINGTON		1990	50 years	100 years
Cascade Province (east and west):				
South Cascades	Establish HCAs with maximum 12-mile spacing	Moderate	High	Very high
North Cascades	Establish HCAs with maximum 7-mile spacing	Moderate to low	Moderate	High
North Cascades/east	Protect 2.1-mile radius around known pairs	Low	Low	Low
Columbia River Gorge	Establish HCA on Forest Service lands and manage State Forest And Park lands (linkage)	Moderate	Moderate[c]	Very High[c]
Olympic Peninsula	Establish HCAs centered on National Park and protect 2.1-mile radius around known pairs; manage State Forest lands and recommend silvicultural techniques (private lands)	Moderate to low	High[c]	High[c]
Southwest Washington	Establish HCAs on State lands and recommend silvicultural techniques (private lands)	Very low	Very low[c]	Low[c]
OREGON				
Cascade Province	Establish HCAs with maximum 12-mile spacing	Very high to high	Very high	Very high
Columbia River Gorge	Establish HCA on Forest Service lands	Moderate	High	Very high
Cascades/east	Establish HCAs with maximum 7-mile spacing and protect 1.5-mile Radius around known pairs	Moderate to low	Moderate	Moderate
Klamath Province	Establish HCAs with maximum 12-mile spacing	Very high to high	Very high	Very high
Coast Range Province	Establish HCAs with maximum 12-mile spacing	Moderate	Moderate[c]	High[c]
Coast Range Area of Special Concern	Establish HCAs with maximum 12-mile spacing and protect 1.5-mile radius around known and future pairs; manage State Forest land recommend silvicultural techniques (private lands)	Low	Low[c]	Moderate[c]

Table T5—continued

Area	Recommended strategy	Current Viability[a]	Viability after adoption of conservation strategy[b]	
CALIFORNIA		1990	50 years	100 years
Klamath Province	Establish HCAs with a maximum 12-mile spacing	Very high to high	Very high	Very high
South Mendocino NF	Establish HCAs with a maximum 7-mile spacing	Low	Low	Moderate
Cascade/Modoc Province:				
Shasta/McCloud Region	Establish HCAs with a maximum 7-mile spacing and protect 1.2-mile radius around known pairs; recommend silvicultural techniques (private lands)	Low to very low	Low[c]	Moderate[c]
North Coast Range Province	Establish HCAs on public lands and recommend silvicultural techniques (private lands)	Moderate	Moderate[c]	High[c]

[a] Viability assessment under current conditions is adapted for USDA (1988)–see Table T2.

[b] Viability assessment developed using a Delphi technique (using table T2 ratings from table T2—USDA 1988).

[c] Assessment assumes that State and private lands contribute to strategy.

Less than full implementation of the strategy, as proposed, such as reducing the size or number of HCAs, increasing the spacing between HCAs, or any changes in strategy implementation in portions of the owl's range, will substantially change the viability assessment and greatly reduce the likelihood of long-term northern spotted owl persistence.

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U

The Committee

Operations of the Committee

The six-member Committee was expected to sign and stand fully responsible for the report. On the rare occasions when all members of the team did not agree on some point, the Committee made the decision. On some other rare occasions, some members of the Committee were not present when decisions were made. Agreement or disagreement of the observer-advisor-staff group with all aspects of the report is thus not implied.

All team members participated fully in all aspects of the effort, and all were accorded the opportunity to assume the same roles in analyzing, interpreting, and formulating the plan. A key objective of the process was to move toward a final decision through achieving consensus at each intermediate step. The filing of a minority report was initially considered possible if substantial disagreement developed among the Committee, but no minority report was needed.

All team members available at particular times participated fully in all activities. Data analysis, synthesis, administrative chores, mapping, writing, technical review, and so on were assigned to the best qualified persons, regardless of their "category" on the team. All team members had equal opportunity to participate.

The entire process was open: anyone who wished to observe Committee activities was welcome, and anyone who wished to present information germane to the mission of the Committee was invited to do so. This open process was followed from the beginning of our activities until March 1,1990, when activities were confined to the Committee and invited technical assistants, to allow preparation of the final report. At that point, all deliberations were complete except for some fine tuning and adjustments resulting from peer review.

Qualifications of the Committee Members

All members of the team were qualified and experienced biologists. Twelve of the 17 team members (and 5 of 6 Committee members) were experienced in dealing with the biology of the northern spotted owl. The curricula vitae of each of team member are detailed below.

Appendix U: The Committee

MARY ANNE BISHOP

Academic Training	**B.B.A.**	University of Wisconsin-Madison; 1974 Real Estate and Urban Land Economics
	M.S.	Texas A&M University; 1984 Wildlife and Fisheries Sciences
	Ph.D.	University of Florida; 1988 Wildlife Ecology
Work Experience	**1979**	Avicultural intern, International Crane foundation, Baraboo, Wisconsin
	1977-80	Zoo keeper, Bird and Large Mammal Departments, San Antonio Zoological Garden and Aquarium, San Antonio, Texas
	1980-82	Biological consultant to Whooping Crane Project, National Audubon Society Research Department, Rockport, Texas
	1983-88	Project biologist, Department of Wildlife and Range Sciences, University of Florida, Gainesville, Florida
	1988-89	Technician, Malacology Lab, Florida Museum of Natural History, Gainesville, Florida
Present Position	**1989-90**	Wildlife biologist, Forestry and Range Sciences Laboratory, USDA Forest Service, Pacific Northwest Experiment Station, La Grande, Oregon

Publications

More than 10 scientific publications primarily dealing with crane ecology and Behavior, and endangered species management.

Professional Societies

American Ornithologist's Union
Wilson Ornithological Society
Society for Conservation Biology
North American Crane Working Group

Special Assignments	**1987**	Visiting researcher, Northwest Plateau Institute of Biology, Academia Sinica, Xining, People's Republic of China
	1989	Visiting researcher, Royal Society for the Protection of Nature, Kingdom of Bhutan
	1989	Consultant, Bombay Natural History Society, Bombay, India, for the U.S. Fish and Wildlife Service, Office of International Affairs
	1990	Visiting researcher, Tibet Plateau Institute of Biology, Lhasa, Tibet, People's Republic of China
Awards	**1982-83**	Rob and Bessie Welder Wilflife Foundation Fellow
	1985	Research Grant, National Audubon Society Science and Sanctuaries Division
	1985-86	Research grants, Florida Chapter Sierra Club

Appendix U: The Committee

CHARLES R. BRUCE

Academic Training	**B.S.**	Lewis and Clark College; Biology
	B.S.	Oregon State University; Wildlife Science
Work Experience	**1971-90**	Nongame wildlife biologist, Oregon Department of Fish and Wildlife at Portland and Corvallis, Oregon
Present Position	Regional nongame biologist, Northwest Region, Oregon Department of Fish and Wildlife, Corvallis, Oregon	
Awards	**1989**	Pride award, Oregon Department of Fish and Wildlife
Professional Societies	The Wildlife Society 1988-89 President, Oregon Chapter	
Experience With Spotted Owl Biology and Management	Interagency management experience for 17 years, including population surveys and development of 1977 and 1981 Oregon spotted owl management plans; chaired interagency Spotted Owl Subcommittee, which drafted management guidelines for the owl throughout its range (1988)	

Appendix U: The Committee

ERIC FORSMAN

Academic Training	**B.S.**	Oregon State University; 1972 Wildlife Management
	M.S.	Oregon State University; 1976 Wildlife Management
	Ph.D.	Oregon State University; 1980 Wildlife Management
Work Experience	**1980-87**	Independent wildlife consultant 1987-89Research wildlife biologist, USDA Forest Service
Present Position	Team leader for Spotted Owl Research, USDA Forest Service, Pacific Northwest Experiment Station, Olympia, Washington	
Publications	Approximately 20, mostly dealing with the biology and management of the spotted owl and other owl species	
Awards	**1984**	Publication award for monographs, The Wildlife Society
Experience With Spotted Owls	**1972-75**	Together with Howard Wight at Oregon State University, investigated the distribution and biology of the spotted owl in Oregon; in addition to surveys to determine the distribution and abundance of the owl, collected information on nest site characteristics, diet, behavior, molt patterns, and roost site selection
	1975-80	Conducted a Ph.D study using radio-telemetry to examine habitat use by spotted owls on the west slope of the Cascades In Oregon
	1976	Conducted a survey comparing the relative abundance of spotted owls in young forests and old-growth forests in northwestern Oregon
	1977	While taking a graduate course at Northern Arizona University, collected information on the distribution and diet of the spotted owl in the Chiricahua Mountains in southeastern Arizona
	1980	Designed and conducted a radio-telemetry study of spotted owls on the Eugene District of the Bureau of Land Management
	1982	Designed and carried out a study in which we measured and compared structural characteristics of old-growth, mature, and young forests of Douglas-fir and western hemlock in northwestern Oregon
	1983-84	Developed and implemented a computerized data base for storing information on the distribution and habitat of spotted owls in Oregon
	1984	Proposed, designed, and carried out a study of the distribution, abundance, and habitat of the great gray owl in south-central Oregon
	1985	Designed and carried out the first extensive survey of spotted owls in British Columbia

ERIC FORSMAN—continued

1985	Bureau of Land Management, Roseburg, Oregon. Assisted with the initiation of a banding study of spotted owls on the Roseburg District
1986	Designed and conducted a survey of spotted owls within the Skagit River drainage in British Columbia
1986	Assisted in an inventory of spotted owls on the Siuslaw National Forest
1986	Conducted a survey to determine the relative abundance of spotted owls in young forests in the northern Coast Ranges of Oregon (a follow-up to the study conducted in 1976)
1973-90	Participated in most of the deliberations of the various committees assembled to address the spotted owl Issue in Oregon. These included the Oregon Endangered Species Task Force, the Oregon-Washington interagency Wildlife Committee, and the Oregon-Washington interagency Spotted Owl Subcommittee
1987-present	As research Wildlife Biologist for the U.S. Forest Service, PNW Research Laboratory in Olympia, Washington, directed several demographic and habitat-use studies on the northern spotted owl in Oregon and Washington

Appendix U: The Committee

GORDON I. GOULD, Jr.

Academic Training

A.B. University of California, Berkeley; 1966 Zoology
M.S. Humboldt State University; 1973 Wildlife Management

Work Experience

1973-74 Contract wildlife biologist, California Department of Fish and Game, U.S. Forest Service, and National Park Service, Sacramento and San Francisco, California

1974-77 Unit wildlife biologist, California Department of Fish and Game, Biythe, California

1977-79 Nongame/furbearer biologist, California Department of Fish and Game, Sacramento, California

Present Position

Nongame bird and mammal and furbearer subproject leader, Wildlife Management Division, California Department of Fish and Game, Sacramento, California

Publications and Papers

Gould, G. I. 1974. The status of the spotted owl in California. California Department of Fish and Game, Wildlife Management Branch. Administrative Report 74-6. 35pp.

Gould, G. I. 1975. Habitat requirements of the spotted owl in California. Cal-Neva Wildl. Trans.:102-117.

Gould, G. I. 1977. Distribution of the spotted owl in California. Western Birds 8:131-146.

Gould, G. I. 1979. Status and management of elf and spotted owls in California. Pages 86-97 *in* P. P. Schaeffer and S. M. Ehlers, eds. Symposium on owls of the West, their ecology and conservation. National Audubon Society, Tiburon, CA.

Gould, G. I. 1985. Management of spotted owls by the California Department of Fish and Game. Pages 21-26 *in* R. J. Gutiérrez and A. B. Carey, eds. Ecology and management of the spotted owl in the Pacific Northwest. USDA Forest Service Gen. Tech. Rep. PNW-185., Portland, OR.

Gould, G. I. 1985. Current and future distribution and abundance of spotted owls in California. Paper presentation and abstract. Symposium on the biology, status, and management of owls, Nov. 9-10, 1985. Raptor Research Found., Sacramento, CA.

Gould, G. 1987. Geography and population trends of spotted owls in California. Presented at Biology and Management of the Spotted Owl—A Briefing for the Chief and Staff, Affected Forest Service Resource Staffs, and Associated Federal and State Agencies, July 27, 1987. USDA Forest Service. Rosslyn, VA.

Gould, G. 1987. Suitable habitat areas for occupancy, reproduction, and dispersal. Presented at Biology and Management of the Spotted Owl—A Briefing for the Chief and Staff, Affected Forest Service Resource Staffs, and Associated Federal and State Agencies, July 27, 1987. USDA Forest Service. Rosslyn, VA.

GORDON I. GOULD, Jr.—continued

Additional publications include about 15 more titles on spotted owls, 20 on bob-cats, and 25 on other nongame bird, mammal, and furbearer topics

Professional Societies	The Wildlife Society Western Field Ornithologists
Special Conservation Biology Assignments	U.S. Fish and Wildlife Service, Endangered Species Scientific Authority, Committee of Bobcat Biologists—Federal Court Case Defense Team
Experience With Spotted Owl Biology or Management	Directed and performed the first two major surveys for spotted owls in California Directed four other major surveys in California Maintain the spotted owl sighting and location information data base for California Planned and was the contract administrator for 15 years of research in five major demographic studies Contract administrator for three habitat studies Helped write the standards and guidelines to establish the current U.S. Forest Service spotted owl management system Performed oversight function on the implementation of the U.S. Forest Service's current spotted owl management system Helped develop the current monitoring system for the U.S. Forest Service's spotted owl management system Has personal knowledge of northern spotted owls, habitat conditions, or both at more than 200 sites in last 17 years

Appendix U: The Committee

A. GRANT GUNDERSON

Academic Training	**B.S.**	California State University, San Jose 1972; Conservation/Wildlife Management
Work Experience	**1973-74**	Wildlife biologist, USDI Bureau of Land Management, San Luis Resource Area, Alamosa, Colorado
	1974-76	Field biologist, USDI Fish and Wildlife Service, Division of Ecological Services, Lafayette, Louisiana
	1976-79	Area wildlife biologist, USDI Bureau of Land Management, Northeast Resource Area, Wheatridge, Colorado
	1980-86	District wildlife biologist, USDA Forest Service, Snow Mountain Ranger District, Ochoco National Forest, Hines, Oregon
	1986	Wildlife biologist, USDA Forest Service, Mount Hood National Forest Supervisors Office, Gresham, Oregon
	1986-88	Wildlife biologist, USDA Forest Service, Pacific Northwest Regional Office, Portland, Oregon
Present Position	Wildlife biologist, Regional Spotted Owl Coordinator, USDA Forest Service, Pacific Northwest Regional Office, Portland, Oregon	
Awards	**1970, 1977—**Outstanding performance awards, USDI Bureau of Land Management **1985, 1988, 1989,1990—**Certificates of merit, USDA Forest Service	
Professional Societies	The Wildlife Society	
Experience Spotted Owl Biology or Management	With Prepared environmental analysis of the effects of timber sales on spotted owls and other wildlife species in the Mount Hood National Forest Served as a member of the Forest Service interdisciplinary team that prepared the Supplemental Environmental impact Statement for spotted owl guidelines in the Pacific Northwest Region; provided guidance to National Forests in Oregon and Washington during the implementation phase after the Chief's Record of Decision, which adopted a management strategy for the spotted owl; reviewed Forest's spotted owl networks. Coordinated the spotted owl Section *7* conferences between National Forests and the U.S. Fish and Wildlife Service Field Offices	

Appendix U: The Committee

DAVID W. HAYS

Academic Training	**B.S.**	Washington State University; Wildlife Biology
Work Experience	**1981 -82**	Wildlife biologist, Okanogan National Forest
	1983	Wildlife biologist, Washington Department of Wildlife
	1983-84	Wildlife biologist, Biosystems Analysis, Inc.
	1985	Wildlife biologist, Washington Department of Wildlife
	1986-88	Wildlife biologist, Beak Consultants, Inc.
Present Position	Wildlife biologist, Nongame Program, Washington Department of Wildlife, Olympia, Washington	
Professional Societies	The Wildlife Society	
Experience With Spotted Owl Biology or Management	**1982**	Surveyed and assessed timber-sale impacts to spotted owls
	1983-85	Radio-telemetry research and habitat evaluation in the Cascade Range of Washington
	1987-88	Surveyed and assessed impacts of a proposed ski development to spotted owls in the southern Cascades of Oregon
	1988-	Currently addresses spotted owl management issues in Washington for Washington Department of Wildlife

Appendix U: The Committee

DOUGLAS B. HOUSTON

Academic Training	**B.S.**	Humboldt State University; 1962 Wildlife Management
	M.A.	University of Wyoming; 1963 Zoology
	Ph.D.	University of Wyoming; 1967 Zoology
Work Experience	**1967-70**	Research biologist, National Park Service; Grand Teton National Park
	1970-80	Research biologist, National Park Service; Yellowstone National Park
Present Position		Research biologist, National Park Service, Northwest Parks Research Group, Olympic National Park
Publications		About 55 publications, primarily on the ecology of moose, elk, and mountain goats, and on the management of National Park ecosystems; includes book: *The northern Yellowstone elk: Ecology and management,* which received the Wildlife Society Publication Award for 1984
Academic Appointments	**1979-81**	Adjunct assistant professor, Oregon State University
	1984-90	Adjunct assistant professor, University of Idaho
Awards		**1979 and 1983**—Superior performance award, National Park Service
		1984—Wildlife Society publication award
Professional Societies		Ecological Society of America
		British Ecological Society
		Natural Areas Association
		Northwest Scientific Association
		Northwest Vertebrate Biology Society
Special Conservation Assignments	**1973**	Determine status of the gray wolf in the greater Yellowstone ecosystem
	1988	Poland; review management of National Parks
	1989	Alaska; document effects of oil spill on National Parks

Appendix U: The Committee

LARRY L. IRWIN

Academic Training	**B.S.**	University of Montana; 1970 WildlIfe Biology
	M.S.	University of Idaho, 1974 Wildlife Management
	Ph.D.	University of idaho, 1978 Wildlife Science
Theses		Relationships between deer and moose on a burn in northeastern Minnesota. M.S. Thesis. 53 pp.
		Relationships between intensive timber culture, big game habitats, and elk habitat selection in northern Idaho. Ph.D. Dissertation. 282 pp.
Professional Interests		Relationships between wildlife populations and their habitats; habitat evaluation for wildlife; habitat management for large mammals; plant succession/wIldfire/wildlife management
Professional Experience	**1970-72**	Biology and general science teacher, Darby, Montana
	1972-74	Graduate research assistant, University of Minnesota and University of Idaho
	1974-78	Research associate and research instructor, University of idaho
	1978-86	Assistant and associate professor (tenured), University of Wyoming
	1986-present	Wildlife program leader, NCASI, Corvallis, Oregon
Publications	**1975-85**	More than 30 scientific publications, primarily dealing with large mammals and habitat relationships, including forest understory succession
	1986-90	Ten publications and reports on northern spotted owls, indicator species, and biodiversity in managed forests; 8 publications on large mammals
Academic Appointments	**1976-78**	Research Instructor, University of Idaho
	1978-86	Assistant and Associate Professor, University of Wyoming
Present Position		Adjunct Associate Professor, Oregon State University
Research in Progress		Habitat ecology of Rocky Mountain bighorn sheep, a 6-year program including four coordinated studies on winter range
		Relationships among deer and elk in managed forests of Washington and Oregon; an experiment with trained elk for gathering data on physiological responses to forests
		Habitat ecology of northern spotted owls in managed forests in Washington, Oregon, and northern California
		Demography of northern spotted owls in managed and unmanaged forests, central Washington

LARRY L. IRWIN—continued

	Habitat use and home range of northern spotted owls in managed forests, western Oregon	
	Biology and forestry implications of marbled murrelets in the Pacific Northwest; survey, capture, and telemetry techniques	
Awards	**1974**	First Pope and Young Club conservation award
	1986	Charles A. Lindbergh grant award for research on balance between man and environment
	1989	Wildlife scientist of the year award, Foundation for North American Wild Sheep
Professional Societies	The Wildlife Society Society for Range Management	
Experience With Spotted Owl Biology or Management	Interagency Spotted Owl Subcommittee, ad hoc committee on spotted owl guidelines	
	Spotted Owl Recovery Plan Committee for State of Washington	
	Supervise several research projects (see Research in Progress, above)	

Appendix U: The Committee

JOSEPH B. LINT

Academic Training	**B.S.**	West Virginia University: 1970 Forest Management
	M.S.	Virginia Tech; 1975 Wildlife Management
Work Experience	**1974-78**	Resource Area and District wildlife biologist, Bureau of Land Management at Coeur d'Alene, Idaho
Present Position		District wildlife biologist, Roseburg District, Bureau of Land Management, Roseburg, Oregon since 1978
Awards		**1983,1987—**Sustained superior performance awards—quality step increase, Bureau of Land Management
		1988—Oregon Society of American Foresters appreciation award
Professional Societies		The Wildlife Society
	1973	President, Virginia Tech Student Chapter
	1982-86	Secretary Treasurer, President-elect, President and Past-President, Oregon Chapter
	1980	Certified Wildlife Biologist
Experience With Spotted Owl Biology or Management	**1978-90**	Participant in continuing development and implementation of strategies for maintaining spotted owl habitat on BLM lands in western Oregon
	1983-90	Field experience in spotted owl surveys for gathering data on spotted owl occupancy and reproduction
	1986-90	Liaison role in cooperative radio-telemetry study in Roseburg area between BLM and USFS Pacific NW Research Station
	1987-90	Cooperator in demographic study of spotted owls in Roseburg area in conjunction with USFS Pacific NW Research Station

Appendix U: The Committee

BRUCE MARCOT

Academic Training	**B.S.**	Humboldt State University; 1977 Natural Resources Planning and interpretation
	M.S.	Humboldt State University; 1978 Natural Resources Science, Wildlife Emphasis
	Ph.D.	Oregon State University; 1984 Wildlife Science
Work Experience	**1977-78**	Contract ecologist, Six Rivers National Forest, Eureka, Califomia
	1978-79	Biological technician, Six Rivers National Forest, Eureka, California
	1980-81	Instructor, Wildlife Department, College of Natural Resources, Humboldt State University, Arcata, California
	1981-83	Graduate research assistant, Cooperative Wildlife Research Unit, Oregon State University, Corvallis
	1983-84	Contract ecologist, Fish and Wildlife Service, Corvallis, Oregon
	1985	Research associate, Cooperative Wildlife Research Unit, Oregon State University, Corvallis
	1985-88	Regional wildlife ecologist, Pacific Northwest Region, Portland, Oregon
Present Position	Area wildlife ecologist, Mount Hood and Gifford Pinchot National Forests, USDA Forest Service, Gresham, Oregon	
Publications/Reports	Forty-eight publications primarily in ecology and wildlife management, expert systems, and artificial intelligence programming.	
Awards	**1971**	Larry Headlee Scholastic achievement award, Saddleback Valley Young Republicans, California: scholarship award and special recognition
	1976	Academic achievement award, Xi Sigma Pi, Humboldt State University, Arcata, California: scholarship award and special recognition
	1976-77	Academic honors, Masters Program, Humboldt State University, Arcata, California
	1977	Certificate of appreciation, The Wildlife Society, Humboldt chapter, for outstanding service as Chair of Conservation Committee
	1977	Joseph S. Woolford, M.D., Rotary Club of Eureka student grant award: scholarship award and special recognition

BRUCE MARCOT—continued

1979 Performance award, USDA Forest Service, 1979. For work, attitude, and contributions at Forest and Regional levels on the Wildlife Habitat Relationships Program, Pacific Southwest Region

1985-86 Listed in Who's Who in Frontiers of Science and Technology

1986 Performance award, USDA Forest Service, for work on analyzing spotted owl population viability, draft spotted owl Supplemental EIS, USDA Forest Service, Pacific Northwest Region, Oregon

1987 Performance award, USDA Forest Service, for teaching ecology and planning of viable populations at Wildlife Habitat Shortcourses

1989 Performance award, USDA Forest Service, special recognition for teaching Forest Service Habitat Shortcourses

1990 Performance award, USDA Forest Service, special recognition for work on Spotted Owl Environmental impact Statement

Professional Societies

The Wildlife Society
- Computer Applications Committee, 1985-present
- Chairman, Conservation Committee, Humboldt Chapter 1977-75

Cooper Ornithological Society
Ecological Society of America
Society for Conservation Biology
Northwest Scientific Association
The Nature Conservancy
American Association for Artificial Intelligence
Computer Society for Social Responsibility
Honor Societies in Natural Resources and Forestry:
- Sigma Xi, Xi Sigma Pi, Phi Kappa Phi, Gamma Sigma Delta

Appendix U: The Committee

E. CHARLES MESLOW

Academic Training	**B.S.**	University of Minnesota; 1959 Fish and Wildlife Management
	M.S.	University of Minnesota; 1966 Wildlife Management
	Ph.D.	University of Wisconsin; 1970 Wildlife Ecology/Zoology
Work Experience	**1959-62**	U.S. Navy
	1968-71	Assistant professor, Zoology/Veterinary Science, North Dakota State University, Fargo
	1971-75	Assistant leader, Oregon Cooperative Wildlife Research Unit, U.S. Fish and Wildlife Service, and Assistant Professor Wildlife Ecology, Oregon State University, Corvallis

Present Position

Leader, Oregon Cooperative Wildlife Research Unit, U.S. Fish and Wildlife Service, and Professor Wildlife Ecology, Oregon State University

Publications

Publications deal largely with forest wildlife and habitat relationships: spotted owls, pileated woodpeckers, snags, forest bird communities, old-growth forest wildlife relationships, black bear ecology, snowshoe hares, great horned owls, Columbian white-tailed deer, and accipiter hawks

Awards

1984 Publication award, The Wildlife Society

Professional Societies

The Wildlife Society 1975
- President, Oregon Chapter 1977-80
- NW Regional Representative 1981-82
- Vice President 1983-86
- President-Elect, President, Past-President

Society of American Foresters
American Society of Mammalogists
American Ornithologists' Union
Cooper Ornithological Society
Wilson Ornithological Society
Ecological Society of America
Society for Conservation Biology
Northwest Scientific Association
International Bear Biology and Management Association
Pacific Northwest Bird and Mammal Society

Special Conservation Biology Assignments

1976-present—Columbian White-tailed Deer Recovery Team

1978-present—IUCN Survival Services Commission, Deer Advisory Group

1983-present—Mount St. Helens Scientific Advisory Board

E. CHARLES MESLOW—continued

Experience With Owl Biology or Management

Principal investigator since 1975 on a succession of northern spotted owl research contracts to Oregon Cooperative Wildlife Research Unit through Oregon State University; contracting agencies include: U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, and Oregon Department of Fish and Wildlife; research topics include: spotted owl distribution, life history, home-range and habitat use, juvenile dispersal, habitat characteristics, great horned owl-spotted owl relation to forest fragmentation, demographic studies, prey ecology, and population studies.

Major professor for E. D. Forsman, G.S. Miller, and three current graduate degree candidates with thesis topics on spotted owls

Since mid-1970's, member of interagency Spotted Owl Management Committees. Member U.S. Fish and Wildlife Service 1989 Northern Spotted Owl Supplementary Status Review Team

Appendix U: The Committee

DENNIS DANIEL MURPHY

Academic Training	**B.S.**	University of California, Berkeley; 1974
	Ph.D.	Stanford University, Palo Alto; 1981
Professional Positions	**1982-83**	Postdoctoral Fellow, Stanford University
	1983-87	Research Associate, Stanford University

Present Position

Senior research associate and Director of the Center for Conservation Biology, Stanford University

Publications

About 100 publications including original research, reviews, and discussion papers on the taxonomy, ecology, genetics, and conservation of butterflies; pertinent to this project and publications on habitat fragmentation and extinction, reserve design and management, population viability analysis, hypothesis testing in conservation biology, and endangered species monitoring: work has appeared in Ecology, American Naturalist, Oecologia, Systematic Zoology, Natural History, Oikos, Conservation Biology, Biological Conservation, Endangered Species Update, Canadian Journal of Zoology, and others, as well as a dozen book chapters

Pertinent Activities

Consultant to U.S. Fish and Wildlife Service on endangered species actions;. science policy council for Glacier National Park; member, Oregon Silverspot Butterfly Recovery Team; member, California Nature Conservancy research committee; designer, Kirby Canyon Conservation Agreement (section 7 consultation); consultant, San Bruno Mountain Habitat Conservation Plan amendment process; consultant to the Pine Barrens Habitat Restoration and Management Plan (Albany, NY); recipient of 1988 Chevron Conservation Award

Appendix U: The Committee

BARRY STUART MULDER

Academic Training	**B.S.**	University of Michigan; 1973 Biology
	M.S.	University of Michigan; 1975 Ecology and Animal Behavior
Work Experience	**1978**	Wildlife biologist, Bureau of Land Management, Riverside, California
	1979-84	Wildlife biologist, Division of Endangered Species, U.S. Fish and Wildlife Service, Washington, D.C.
	1984-88	Supervisory fish and wildlife biologist, Division of Endangered Species, U.S. Fish and Wildlife Service, Denver, Colorado; Chairman, Upper Colorado River Endangered Ashes Coordinating Committee
Present Position	Coordinator, Spotted Owl Program, U.S. Fish and Wildlife Service, Portland, Oregon	
Publications/Reports	**USDI. 1987.** Upper Colorado River Endangered Fishes Conservation Plan. Inter-agency Report. U.S. Fish and Wildlife Service. Denver, Colorado	
	USDI. 1987. The Northern Spotted Owl Status Review. Final Report. U.S. Fish and Wildlife Service. Portland, Oregon	
	USDI. 1989. The Northern Spotted Owl Status Review Supplement. Final Report. U.S. Fish and Wildlife Service. Portland, Oregon	
Academic Experience	**1975-78**	Teaching assistant, Biology Department, University of Michigan

Appendix U: The Committee

BARRY RICHARD NOON

Academic Training

B.A. Princeton University: 1971 Biology University of Vermont; 1972-73 Biology

Ph.D. State University of New York: 1977 Biology

Postdoctoral Experiences

1977-78 Research scientist (statistical analysis and computer programming), New York State Department of Health, Department of Epidemiology and Human Ecology, Albany, New York

Work Experience

1978-79 Instructor of field ornithology, College of Environmental Science and Forestry, State University of New York, Syracuse, New York

1978-79 Assistant professor, Department of Biology, Siena College, Loudonville, New York

1979-81 Wildlife biologist, Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service, Laurel, Maryland

1980-85 Senior adjunct research associate, Adirondack Ecological Center, Department of Environmental and Forest Biology, State University of New York, Syracuse

1986-87 Director of graduate studies, College of Natural Resources, Humboldt State University, Arcata, California

1980-87 Associate professor, Department of Wildlife, College of Natural Resources, Humboldt State University, Arcata, California

Present Position

Project leader, USDA Forest Service, Redwood Sciences Laboratory, Arcata, California

Publications

Forty publications, primarily in avian ecology, population and community ecology, and biometrics.

Awards

1975 Sigma Xi Award

1976 American Ornithologist's Union Student Membership Award

1977 Wilson Ornithological Society Student Membership Award

1977 Marcia Brady Tucker Award: awarded by the American Ornithologist's Union to enable presentation of a graduate student paper at the AOU's annual meeting

1979 Paul C. Lemon Award: awarded by the State University of New York at Albany for the outstanding doctoral thesis in environmental biology/ecology for the years 1977-78

BARRY RICHARD NOON—continued

1980-85 Senior adjunct research associate, State University of New York at Syracuse; title granted for continuing research and involvement with graduate students at the Adirondack Ecological Center, Newcomb, New York

1986 Honorary position of Elective Fellow of the American Ornithologist's Union for significant contributions to the field of ornithology

1986 Certificate of appreciation from the U.S. Forest Service for significant contributions to the Old-Growth Wildlife-Habitat Research Program

1987 Meritorious performance award from the College of Natural Resources, Humboldt State University, for excellence in teaching and service

Memberships in Professional Societies

The American Ornithologists' Union
The American Society of Naturalists
The Cooper Ornithological Society
The Ecological Society of America
The Wildlife Society
Wilson Ornithological Society

Experience With Spotted Owls

Leader of large wildlife research unit which, as part of its mission, has been conducting research on the spotted owl, and its primary prey, for 3 1/2 years: for the last 2 years, along with several colleagues, have been studying the mathematical demography and population ecology of spotted owls

Appendix U: The Committee

JACK WARD THOMAS

Academic Training	**B.S.**	Texas A&M University; 1957 Wildlife Management
	M.S.	West Virginia University: 1969 Wildlife Ecology
	Ph.D.	University of Massachusetts; 1972 Forestry (Natural Resources Planning Option)
Work Experience	**1957-66**	Wildlife biologist and project leader, Texas Parks and Wildlife Department at Sonora and Llano, Texas
	1966-70	Research wildlife biologist, USDA Forest Service, Morgantown, West Virginia
	1970-74	Research wildlife biologist and project leader for Urban Forestry Research, USDA Forest Service, Amherst, Massachusetts

Present Position

Project leader and chief research wildlife biologist, Range and Wildlife Habitat Research, USDA Forest Service, Pacific Northwest Research Station, La Grande, Oregon

Publications

About 250; primarily in elk, deer, and turkey biology; wildlife disease: wildlife habitat; songbird ecology, and land-use planning: publications both in technical formats and popularized form includes several award-winning books—The *Elk of North America—Ecology and Management, Wildlife Habitats in Managed Forests—The Blue Mountains of Oregon and Washington, and Wildlife Habitats in Managed Rangelands—The Great Basin of Southeastern Oregon*

Academic Appointments	**1966-70**	Adjunct professor, West Virginia University
	1970-73	Adjunct faculty, University of Massachusetts
	1973-present	Adjunct professor, Eastern Oregon State College
	1974-present	Adjunct professor, Oregon State University
	1975-present	Adjunct professor, Washington State University
	1976-present	Adjunct professor, University of Idaho
Awards Include	**1976 and 1983**	Publication awards, The Wildlife Society
	1979	Oregon Wildlife Society award
	1981	Einarsen award, NW Section, The Wildlife Society
	1967,1969, 1972, 1976, 1979,1980, 1982, 1984, 1987, and 1989 (2)	Certificates of merit with cash awards, USDA Forest Service
	1983	Gulf Oil conservation award
	1983	Special recognition award; service award, The Wildlife Society
	1984	Natural Resource employee of the year for Oregon, National Wildlife Federation
	1985	Distinguished service award (the highest award that can be made to a USDA employee), U.S. Department of Agriculture
	1985	Earle A. Childs Award, High Desert Museum, Bend, OR
	1986	Distinguished citizen of the year award, Eastern Oregon State College

JACK WARD THOMAS—continued

Professional Societies		Society of American Foresters
	1981-84	Editorial Board, Journal of Forestry
	1985-90	Editorial Board, Western Journal of Applied Forestry
	1982	Publicity chairman, Oregon Society of American Foresters, Annual Meeting
	1983-84	SAF Task Force on Harvest Scheduling of Old-Growth Forests
	1986	Elected Fellow
	1988-90	Committee to Select Recipient of Research Achievement Award, Oregon SAF
		The Wildlife Society
	1966-67	President, Texas Chapter
	1966-67	Various committee assignments including: Nominations Committee (Chairman); Ad Hoc Committee to Prepare Position Statement of Old-Growth Forests (Chairman); Leopold Medal Committee (Chairman); Leopold Medal Committee (member)
	1971-72	NE Regional Representative
	1976-78	President-Elect, President, and Past-President
		The Society for Range Management
		The Wilson Ornithological Society
		American Society of Mammalogists
		American Ornithologists' Union
		Society for Conservation Biology
Special Assignments	**1980**	Pakistan, PL-480 assignment to set up big-game surveys
	1980-81	National Academy of Sciences (National Research Council) Committee to Evaluate the Status of Management of the Public Rangelands
	1982	India, PL-480 assignment to train wildlife/forestry professional
	1987	U.S. representative. Workshop on Wildlife Utilization, Assissi, Italy
	1989	Ecological Review Team, Yellowstone National Park
	1989-90	National Academy of Sciences (National Research Council) Committee to Evaluate the National Status of Rangeland Inventories
	1989-91	U.S. Teaching Team (USDA Forest Service) for Graduate Training, Wildlife institute of India

Appendix U: The Committee

JARED VERNER

Academic Training	**B.S.**	Washington State University; 1957 Wildlife Management
	M.S.	Louisiana State University; 1959 Zoology
	Ph.D.	University of Washington; 1963 Zoology
Work Experience	**1963-65**	Postdoctoral research fellow, University of California, Berkeley
	1965-73	Assistant professor, Associate professor, and professor of biology, Central Washington University, Ellensburg
	1973-76	Professor of ecology, Illinois State University, Normal; Section Head, Environmental and Systematic Biology, 1974-76
	1976-86	Principal research wildlife biologist and project leader, Wildlife and Range Research, USDA Forest Service, Fresno, California

Present Position

Project leader and chief research wildlife biologist; Wildlife, Range, and Monitoring Research, USDA Forest Service, Pacific Southwest Forest and Range Station, Fresno, California

Publications

Ninety publications, more than half in refereed outlets. Most have treated aspects of the ecology, behavior, evolution, management, and monitoring of birds; includes lead editorship of two award-winning books: *California Wildlife and Their Habitats: Western Sierra Nevada, and Wildlife 2000: Modeling Habitat Relationships of Terrestrial Vertebrates.*

Awards and Recognition

1953	Lions' Club scholarship
1954	Phi Sigma (scholastic honorary society)
1957	Phi Beta Kappa and Phi Kappa Phi (scholastic honoraries)
1958	Sigma Xi
1958	Tucker Award, American Ornithologists' Union
1960, 1961, and 1962	Predoctoral fellowships, National Science Foundation
1963-65	Postdoctoral fellowship, National Science Foundation
1966,1968	Research grants, National Science Foundation
1971	Elected voting member of the American Ornithologists' Union
1977	Elected Fellow of the American Ornithologists' Union
1980	Quality step increase
1980	Publication award, National Association of Government Communicators, Washington, D.C.
1982 and 1987	Program reviews, citing individual research accomplishments and leadership for productivity of the research work unit in Fresno
1983, 1984, 1985, 1986, 1987,1988, 1989	Special commendations from review boards for Combined Certificates of merit with cash awards, USDA Forest Service
1986	Publication award, The Wildlife Society

JARED VERNER—continued

	1987	Distinguished Scientist, with Cash Award, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station

Professional Societies

American Ornithologists' Union
1975-76 Brewster and Coues Awards Committee
1975-79 Committee on Public Concerns
1984-87 Nominations Committee for Elective Members and Fellows; Chairman,

Cooper Ornithological Society
1977 and Conservation and Resolutions Committee;
1983-85 Chairman
1984-87 Board of Directors
1985 Chairman, Nomination Committee for Board of Directors
1985-86 Chairman, By-Laws Committee
1987-89 President Elect
1989-91 President

Wilson Ornithological Society
1975-77 Fuertes/Nice Awards Committee
1976-77 Chairman

International Commission on Bird Preservation
1982-85 Habitat Committee, World Working Group on Birds of Prey

Ecological Society of American
The Wildlife Society
Society for Conservation Biology
Association of Field Ornithologists
Western Field Ornithologists
North American Bird Banding Association

Special Assignments

1982	Technical advisory group to develop guidelines for the USDA Research and Development Program on Old-Growth Forest in the Pacific Northwest, USDA Forest Service
1977-present	California Condor Recovery Team
1981-present	Pacific Southwest Forest and Range Experiment Station's representative on the national steering committee for developing the Wildlife-Habitat Relationships Program
1985-1986	Member, National Audubon Society's "Blue Ribbon Panel" to evaluate the management program for the northern spotted owl
1989-1990	Member, Planning Team for National Workshop on Monitoring of Biological Resources, USDA Forest Service, Washington, D.C.

Appendix U: The Committee

DAVID SAMUEL WILCOVE

Academic Training	**B.S.**	Vale University; 1980 Biology
	M.A.	Princeton University; 1982 Biology
	Ph.D.	Princeton University; 1985 Biology
Work Experience	**1980-84**	Teaching assistant, Princeton University
	1985-86	Research scientist in zoology, The Nature Conservancy
Present Position		Senior ecologist, The Wilderness Society, Washington, DC
Publications		Over 30 publications, including original research, reviews, and popular articles on conservation biology and ornithology; work has appeared in Ecology, Wilson Bulletin, Nature, Conservation Biology, Natural History, Audubon, and as chapters in several books.
Professional Appointments	**1989-present**	Board of Editors, Conservation Biology
	1989-present	Board of Directors, international Council for Bird Preservation, U.S. and Pan American Sections
	1989-present	Chairman, Committee on Public Responsibilities, American Ornithologists' Union
	1987-90	Board of Directors, Natural Areas Association

V

Glossary

ACEC—area of critical environmental concern; used specifically on lands administered by the BLM

adaptive management—process of implementing policy decisions as scientifically driven management experiments that test predictions and assumptions in management plans

agreement areas—also BLM-ODFW agreement areas; spotted owl habitat areas protected by the BLM under a cooperative agreement with the ODFW

algorithm—mathematical rule for solving a problem

Allee effect—a depression in the encounter rate between males and females resulting from low population densities: the probability of finding a mate drops below that required to maintain the reproductive rates necessary to support the population

animal damage—damage caused to trees by animals, often by rodents or large mammals

awarded sales—Federal timber sales that have been let to the successful bidder through a formal contract

basal area—the area of the cross-section of a tree stem near its base, generally at breast height and inclusive of bark

biological diversity—the variety of life's forms—that is plants, birds, insects, and so on

biomass—the total quantity (at any given time) of living organisms of one or more species per unit of space, or of all the species in a biotic community

birth-pulse population—a population assumed to produce all of its offspring at an identical, and instantaneous, point during the annual cycle

blowdown—trees felled by high winds

bottleneck—see "population bottleneck"

Appendix V: Glossary and Scientific Names

broom trees—trees in which tops have broken off and secondary limbs have grown up to overtop the stump, forming a group of tops that are often broom-shaped

California Habitat Conservation Plan—a conservation plan for the northern spotted owl currently being developed by the California Resources Agency

canopy closure—the degree to which the crowns of trees are nearing general contact with one another

carrying capacity—the maximum number of animals that can be sustained over the long-term on a specified land area

center of activity—owl's nest site or primary roost area

checkerboard ownership—a land ownership pattern in which every other section (square mile) is in Federal ownership as a result of Federal land grants to early western railroad companies

closed population—an isolated population of individuals that receives no immigrants from other populations

coevolution—sharing a common, and interdependent, evolutionary history

cohort—individuals all resulting from the same birth-pulse, and thus all of the same age

colonization—the act or process of establishing a new colony or population

commercial forest land—forest land tentatively suitable for the production of crops of timber and that has not been withdrawn for other reasons

connectivity—a measure of the extent to which intervening habitat truly connects HCAs for juvenile spotted owls dispersing between them

core area—a defined area that includes the center of activity of a pair including the nest site if known

corridor—a defined tract of land, usually linear, through which a species must travel to reach habitat suitable for reproduction and other life-sustaining needs

dedicated land—lands that are withdrawn from production of commodity resources

Delphi technique—the process of combining expert opinions into a consensus; a method of making predictions

demographic stochasticity—random fluctuations in birth and death rates

density-dependent—a process, such as fecundity, whose value depends on the number of animals in the population per unit area

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depensatory fecundity—the maximum value for fecundity occurs at some optimal density, with fecundity decreasing at either higher or lower densities

dispersal—the movement, usually one way, and on any time scale, of plants or animals from their point of origin to another location where they subsequently produce offspring

dispersal corridor—a corridor through which young disperse from their area of birth

dispersal capability—ability of members of a species to move from their area of birth to another suitable location and subsequently breed

dispersal distance—a straight-line distance that an individual travels from its birth place until it stops dispersing (assumed to be a breeding site) or dies

ecological dependency—an absolute reliance on one or more environmental factors for viability; removal of the factor(s) will lead to the species' extinction

ecological integrity—the condition in which all key components of an ecological system are intact and functioning normally

ecosystem texture—see "texture of an ecosystem"

edge-dependent species—species that require the interface between two adjacent plant communities or successional stages to meet habitat requirements

edge effects—differences in microclimate, flora, fauna, stand structure, habitat values, stand integrity (including resistance to being blown down by high winds) that occurs in or as a result of a transition zone where two plant communities or successional stages are joined

emigration—permanent movement of individuals of a species from a population

environmental stochasticity—random variation in environmental attributes such as temperature, precipitation, and fire frequency

eutrophic—condition of a body of water in which the increase of mineral and organic nutrients has reduced the dissolved oxygen, producing an environment that favors plants over animal life

even-aged forest—a forest stand composed of trees with less than a 20-year difference in age

extinction rate—the number of elements (individuals, populations, species) lost per unit of time

extinction time—predicted period of time for a population to become extinct

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feathered—condition of a stand in which the basal area per unit area is gradually reduced, through selective harvest, from a natural or fully stocked stand outward toward a clearcut

fecundity—number of female young produced per adult

female floaters—nonbreeding adults and subadults that move and live within a breeding population, often replacing breeding adults that die; nonterritorial individuals

forest landscape—land presently forested or formerly forested and not currently developed for nonforest use

founder effects—decrease in genetic variability from establishment of a new population by few individuals

fragmentation—process of reducing size and connectivity of stands that comprise a forest

fuel loading—the amount of combustible material present per unit of area, usually expressed in tons per acre

gene flow—rate of movement of genetic material between populations

gene frequency—how often a particular gene is encountered among a random sample of individuals

genetic deterioration—loss of genetic variability that results from population isolation or decline

genetic stochasticity—random changes in gene frequencies from such factors as inbreeding

genetic variability—the number of different genes possessed by an individual or population

habitat capability—capacity of a habitat to support an estimated number of pairs of a species

Habitat Conservation Area—a contiguous block of habitat to be managed and conserved for breeding pairs, connectivity, and distribution of owls; application may vary throughout the range according to local conditions

habitat fragmentation—see “fragmentation”

habitat mosaic—the mix of habitat conditions across the landscape

habitat-niche—the specific arrangement of food, cover, and water that meets the annual requirements of a particular species

Hatfield-Adams amendment—Section 318 of Public Law 101-1 21, October 1989

home range—the area to which the activities of an animal are confined during a defined period of time

home-range of a pair—the sum of the home ranges of each member of a pair minus the area of home-range overlap

home-range overlap—percentage of the home ranges of two adjacent individuals that they share

interbirth interval—the interval between birth pulses

internal recruitment—maturing of new breeding individuals in a local population that were born within that same population

keystone species—an individual species that dominates structure and function in an ecosystem, and on which the viabilities of one or more additional species may depend

lambda—the finite rate of population change (population size in year 2 divided by the population size in year 1)

lands not suited for timber production—lands incapable of producing 20 cubic feet per acre per year or lands withdrawn from commercial forest harvest for other reasons (see reserved lands)

lands suited for timber production—commercial forest land identified as appropriate for timber production

large sawtimber—forest stands that are characterized by trees that are ≥21 inches in d.b.h.

leave strips—generally narrow bands of forest trees that are left along streams and rivers to buffer aquatic habitats from upslope forest management activities

legacy—remnant trees of original forest stands, both alive and dead, that are left on harvest units to assist in meeting habitat requirements of various species In the next forest rotation, as well as to provide genetic continuity

Leslie matrix—a two-dimensional array (rows and columns) whose elements represent the birth and death rates of a population

life table—mathematical table illustrating the age-specific birth and death rates of a population

linear model—a combination of random variables none of which have exponents that differ from 1.0

linear regression model—an equation that explains some amount of the variation in a dependent variable with a linear combination of one or more independent variables

long term—here, 50 to 100 years and sometimes beyond

managed forest—forest land that is harvested on a scheduled basis and contributes to an allowable sale quantity

metapopulation—a population comprised of a set of populations that are linked by migrants, allowing for recolonization of unoccupied habitat patches after local extinction events

microenvironment—the sum total of all the external conditions that may influence organisms and that come to bear in a small or restricted area

microhabitats—a restricted set of distinctive environmental conditions that constitute a small habitat, such as the area under a log

minimum convex polygon technique—a method of estimating home-range size, in which the smallest possible convex polygon is drawn around the outermost locations where an animal was observed; the area within the polygon is then calculated

mixed-conifer forest—a forest community that is dominated by two or more coniferous species

mixed-evergreen forest—a forest community that is dominated by two or more species of broad-leaved hardwoods whose foliage persists for several years; important western species include madrone, tanoak, chinkapin, canyon live oak, and California-laurel

model—an idealized representation of reality developed to describe, analyze, or understand the behavior of some aspect of it; a mathematical representation of the relationships under study

monitoring—a process of collecting information to evaluate whether or not objectives of a management plan are being realized

monitoring program—see “monitoring”; the program used to monitor a population and its habitat

mutualism—a positive association between two organisms; a symbiotic relation

natal cluster—a group of adjacent animal territories, in one of which an individual was born

niche—see “habitat niche”

null hypothesis—no difference is anticipated in test comparisons

old growth—a forest stand with moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; a high incidence of large trees with large, broken tops, and other indications of decadence; numerous large snags; and heavy accumulations of logs and other woody debris on the ground

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pair site—an amount of habitat that is considered capable of supporting one pair of spotted owls

physiographic province—a geographic region in which climate and geology have given rise to a distinct array of land forms and habitats

population—collection of individuals that share a common gene pool

population bottleneck—the phenomenon experienced by a small population that is susceptible to the deleterious effects of demographic and genetic stochasticity; also a zone of constriction in the distribution of a population

population density—number of individuals of a species per unit area

population persistence—general term for the capacity of a population to maintain sufficient numbers and distribution over time

population viability—probability that a population will persist for a specified period of time across its range despite normal fluctuations in population and environmental conditions

power analysis—a statistical method for controlling for the probability of making a type 2 error, or attempting to place limits on the probability of failing to reject a null hypothesis that is false

refugia—havens of safety where populations have high probability of surviving periods of adversity

regulated forest—theoretical managed forest from which the same acreage of stands can be harvested annually in perpetuity

rescue effect—periodic immigration of new individuals sufficient to maintain a population that might otherwise decline toward extinction

reserved land—Federal lands, often in preserved or protected status, that have been removed from the acreage base used to calculate timber yields: for example, Wilderness Areas or Parks

reserves—tract of forest temporarily or permanently set aside from timber harvesting

restricted harvest—land either withdrawn from timber harvest or where timber production is limited to less than clearcutting

rotation—the planned number of years between the regeneration of an even-aged stand and its final cutting at a specified stage

sale under contract—Federal timber sales that have been let to the successful bidder through a formal contract

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search capability—the ability of a dispersing juvenile or adult owl to locate suitable habitat

search efficiency—proportion of dispersing juveniles or adults that locate minimally suitable habitat before they die

search time—number of days required for an average dispersing individual to locate suitable or better habitat

secondary crown—live limbs that grow upward to form a new crown in a tree after the original top breaks off

secondary population—population occupying suboptimal habitat

sensitivity coefficient—term that measures relative degree of change in outcome of a mathematical expression or equation after a specified change in an individual component

short term—here, 1 to 50 years

sink—population whose average reproductive rate is less than its average rate of mortality; area that attracts immigrants not expected to contribute significantly to future populations (see "source")

SLOSS debate—disagreement among scientists as to the relative value to the conservation of biological diversity provided by a "single large or several small" reserves totaling the same area

snag—standing dead tree

social facilitation—process of aiding a biological function or activity through behavioral interaction

social stimulation—biological process that increases in intensity or effect through group behavior of a species

source—an actively breeding population that has an average birth rate that exceeds its average death rate; produces an excess number of juveniles that may disperse to other areas

spectral signature—specific combination of wavelengths of light energy reflected or radiated from a land surface, or, in forestry, a wavelength combination that more or less characterizes a specific forest condition or successional stage

standards and guidelines—directions generated and followed by the Committee in developing the HCAs and their location in the landscape: the standards and guidelines also provide instructions to managers for use in carrying out the management strategy

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stepping stones—relatively small, isolated patches of habitat that provide sufficient resources to support individuals as they disperse from one location to another

stochastic—random, uncertain; involving a random variable

stochastic fecundity—random fluctuation n a population's rate of producing female offspring

subpopulation—a well-defined set of interacting individuals that comprise a proportion of a larger, interbreeding population

suitable habitat—here, an area of forest vegetation with the age-class, species of trees, structure, sufficient area, and adequate food source to meet some or all of the life needs of the northern spotted owl

superior habitat—here, habitat selected in excess of availability by the majority of individual northern spotted owls

sustained yield or production—the amount of timber that a forest can produce continuously from a given intensity of management; implies continuous production; a primary goal is to achieve a balance between incremental growth and cutting

territory—the area that an animal defends, usually during breeding season, against intruders of its own species

texture of an ecosystem—relative surface smoothness of an ecosystem as determined by remote sensing technology, or the distinctiveness of the transition between two distinct ecosystems

threshold phenomenon—pattern or trend in population growth rate that exhibits relatively long periods of slow change followed by precipitous increase or decrease in response to an environmental gradient

turnover—a term in population analysis that indicates the rate or number of identifiable adults that die during a specified period

type 2 error—statistical term for the error that is made when a null hypothesis that is false is not rejected; that is, concluding that no difference exists in a comparison between two populations when a difference does exist

vagility—capacity of any organism to become widely dispersed

variance—a statistical term that indicates a measure of variability within a finite population of a sample; the total of the squared deviations of each observation from the arithmetical mean divided by one less than the total number of observations

viability—ability of a population to maintain sufficient size so that it persists over time In spite of normal fluctuations in numbers; usually expressed as a probability of maintaining a specific population for a specified period

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vital rate—collective term for the age-specific birth and death rates of a population

windthrow—a tree or group of trees uprooted by the wind

wink out—local extinction of subpopulations of a larger population

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Table V1—Scientific names of plants and animals mentioned in this report

Common name	Scientific name
Birds	
blackbird, red-winged	*Agelaius phoeniceus*
chickadee, black-capped	*Parus atricapillus*
chough	*Pyrrhocorax pyrrhocorax*
crane, whooping	*Grus americana*
crow, carrion	*Corvus corone*
dove, stock	*Columbia livia*
eagle	
bald	*Haliaeetus leucocephalus*
harpy	*Harpia harpyja*
falcon, peregrine	*Falco peregrinus*
goshawk, northern	*Accipiter gentilis*
grouse, ruffed	*Bonasa umbellus*
hawk	
Cooper's	*Accipiter cooperii*
Socorro island red-tailed	*Buteo jamaicensis socorroensis*
hen, heath	*Tympanuchus cupido cupido*
jackdaw	*Corvus modelula*
meadowlark, pampas	*Sturnella defilippii*
moorhen	*Gallinula chloropus*
osprey	*Pandion haliaetus*
owl	
barred	*Strix varia*
California spotted	*Strix occidentalis occidentalis*
great horned	*Bubo virginianus*
little	*Athene noctua*
Mexican spotted	*Strix occidentalis lucida*
northern spotted	*Strix occidentalis caurina*
tawny	*Strix aluco*
parakeet, Carolina	*Conuropsis carolinensis*
parrot, Puerto Rican	*Amazona vittata*
pigeon	
passenger	*Ectopistes migratorius*
wood	*Columba palumbas*
plover, ringed	*Charadrius hiaticula*
raven	*Corvus corax*
sparrow	
dusky seaside	*Ammodramus maritimus nigrescens*
rufous-collared	*Zonotrichia capensis*
sparrowhawk	*Accipiter nisus*
woodpecker	
ivory-billed	*Campephilus principalis*
pileated	*Dryocopus pileatus*
wren, sedge	*Cistothorus platensis*

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Table V1—continued

Common name	Scientific name
Fish	
salmon	*Oncorhynchus* spp.
Insects	
butterfly	
bay checkerspot	*Euphydryas editha bayensis*
Karner blue	*Lycaeides melissa samuelis*
large blue	*Maculinea arion*
Mammals	
agouti	*Dasyprocta* spp.
armadillo	*Dasyprus novemcinctus*
bear, grizzly	*Ursus arctos horribilis*
bison	*Bison bison*
coatimundi	*Nasua narica*
ferret, black-footed	*Mustela nigripes*
gopher, pocket	*Thomomys* spp.
hare, snowshoe	*Lepus americanus*
jaguar	*Panthera onca*
marten, pine	*Martes americana*
mouse	
deer	*Peromyscus* spp.
forest deer	*Peromyscus oreas*
peccary, collared	*Tayasso tajacu*
pika	*Ochotona princeps*
puma	*Felis concolor*
rabbit, brush	*Sylvilagus bachmani*
squirrel, northern flying	*Glaucomys sabrinus*
woodrat	
bushy-tailed	*Neotoma cinerea*
dusky-footed	*Neotoma fuscipes*
vole	
Amargosa meadow	*Microtus californicus scirpensis*
redtree	*Arborimus longicaudus*
southern red-backed	*Clethrionomys occidentalis*
western red-backed	*Clethrionomys gapperi*
Reptiles	
lizard, fringe-toed	*Uma notata*
Trees	
alder, red	*Alnus rubra*
buckeye, California	*Aesculus californica*
California-laurel	*Umbellularia californica*
chinkapin, giant	*Castanopsis chrysophylla*

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Table V1—continued

Common name	Scientific name
Douglas-fir	*Pseudotsuga menziesii*
fir	
grand	*Abies grandis*
Pacific silver	*Abies amabilis*
white	*Abies concolor*
hemlock, western	*Tsuga heterophylla*
incense-cedar	*Libocedrus decurrens*
madrone, Pacific	*Arbutus menziesii*
oak	
blue	*Quercus douglasii*
California black	*Quercus kellogii*
canyon live	*Quercus chrysolepis*
interior live	*Quercus wislizeni*
Oregon white	*Quercus garryana*
pine	
ponderosa	*Pinus ponderosa*
sugar	*Pinus lambertiana*
Port-Orford-cedar	*Chamaecyparis lawsoniana*
redcedar, western	*Thuja plicata*
redwood	*Sequoia sempervirens*
spruce, sitka	*Picea sitchensis*
sycamore, California	*Platanus racemosa*
tanoak	*Lithocarpus densiflorus*
Diseases	
dwarf mistletoe	*Arceuthobium* spp.

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